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NOTES AND COMMENTS.

A Warning and a Lead.

We hear much loose talk nowadays about industrial supremacy in the future, capturing the world's markets, facing German competition, and utilising our Imperial resources; while the nostrums proffered range from new systems of taxation to the mechanicalising of all possible operations, and other more or less practicable ventures. But far too little is heard of the more important subject of workers' efficiency and how to obtain it. Nor must we imagine that we are the only nation bent on industrial supremacy. There is a movement on foot in the United States which may well be taken as a serious warning and a good lead to British manufacturers.

On March 6, 1915, representatives of five American associations of employers met to consider the feasibility of joint action on matters pertaining to the training of apprentices and to the development of skilled workers in industry generally. The meeting was arranged because many employers felt that the time had arrived when united action ought to be taken to bring about close and effective co-operation among associations of employers, and among employers generally, in respect to the training of skilled and semi-skilled employés in industry. The associations officially represented at the meeting were the National Association of Manufacturers, the National Founders' Association, the National Metal Trades Association, the United Typothetæ and Franklin Clubs of America, and the National Machine Tool Builders' Association.

After the representatives of each association had outlined the conditions prevailing in their industries, and had discussed the necessity of developing comprehensive plans for the proper training of skilled and semi-skilled workers through apprenticeship systems for the young and through specialised training courses for adults, it was unanimously agreed that a large amount of effective work could be accomplished by close co-operation of the interests represented. Accordingly, it was decided to organise a Conference Board on Training of Apprentices, to consist of the president and two other delegates from each of the five associations represented at the meeting and from such other qualified associations as might desire to co-operate in the work. The Conference Board decided to devote its early meetings to the consideration of the problem of training apprentices, both in its broad, fundamental aspect and in its more specific application to various industries, to the end that a well-defined and comprehensive programme might in due time be adopted and published. With such a programme for a guide and with competent experts appointed by and working under the Conference Board, stimulating and assisting employers, the latter, it was thought, should then be expected to do their share in the effective training of junior employés. The Conference Board outlined the scope of its work by the adoption of the following declaration:—

"The Conference Board on Training of Apprentices is organised to promote co-operation among employers in training employés 'for industry in industry' and to impress upon employers their peculiar responsibility in this respect; to stimulate the establishment in employments of effective apprenticeship systems for young people based on co-ordinated trade training and technical instruction, and of specialised training courses for men and women; to devise plans and make recommendations to employers for the accomplishment of this purpose; and to co-operate with all public and private agencies engaged in effective preparation of young people for industrial life."

As a result of its deliberations during the first year the Conference Board agreed upon certain fundamental principles as the common basis of all apprenticeship training, recommendations to employers upon the various phases of apprenticeship training, a suggested form of indenture for use in all industries, and that a certificate of apprenticeship be given to all apprentices who successfully complete their apprenticeship. A series of bulletins, entitled "Practical Apprenticeship," is to be issued containing the findings and recommendations of the Conference Board. Already one on "Necessity of Apprenticeship" has been issued as the first of the series, and is reproduced *in extenso* on another page. Other bulletins will deal with "Fundamentals of Apprenticeship," "Practical Training," "Applied Technical Instruction," "Specialised Training Courses," "Employers and the Schools," and such subjects of similar import as may be determined upon.

British Action.

In this country the subject above referred to has also had some consideration, but we still lack any definite movement on the part of employers generally to co-operate in the matter. Various associations and bodies have attempted to awaken interest in apprentice training and schooling, and in the foundry industry a definite start was made by the British Foundrymen's Association, who appointed a strong Committee to investigate and report on the matter and make suggestions as to action. The activities of this Committee are for the moment suspended on account of the war and its demands, but very soon—possibly before the declaration of peace—it will be found desirable to resume the investigation.

For our part, we are not quite convinced that sectional action like this will meet with the reward it deserves, for the subject is essentially a national one, and what applies to one trade also applies to others, with minor modifications. But the foundrymen's action may give a lead to others, and start a general movement in the direction of systematic training and schooling of young employés. Once the weight of Governmental support is definitely secured on the side of such a movement much will be possible, and on a scale beyond the reach of individual or sectional effort. Whether that support will be given without pressure, however, remains to be seen, but it is for the men in the industry to demand it and not wait for the Government to proffer it. Any scheme of training for efficiency requires facilities, and these should be more or less uniform throughout the country. Only on a national basis, however, can this be secured.

Further, the requirements of any particular industry can only be properly determined from inside. It is hardly to be expected that Government Ministers or officials will possess the intimate knowledge of each trade necessary for properly meeting its needs, however admirably the broad general lines of a national scheme may be conceived. It is for those actually in the industry to offer the Government the advice they alone can give, and offer it with all the weight the trade can command.

Iron and Steel Institute.

It is interesting to note that a distinct move in the direction of bringing its operations into closer touch with industrial work has been made by the Iron and Steel Institute. It was announced at last month's meeting that the Institute had decided to form five Scientific and Technical Committees, on the lines adopted by the American Institute of Mining Engineers and the German Verein Deutsche Eisenhüttenleute. These committees will be five in number, and will deal with:—(*a*) Mining fuel refractories; (*b*) Pig-iron foundry practice; (*c*) Steel and alloys; (*d*) Mechanical treatment; (*e*) Physics, chemistry, and microscopy.

It is proposed that these Committees shall consist of about eight, of whom one or more will be a member of Council, while the others will be chosen from among the members. These members of the Technical Committees will be nominated by the members of the Institute themselves. The Committeemen will be appointed for four years, and one-half will retire every two years, so that a continual infusion of fresh blood should occur. This will mean at least 30 or 40 members actively concerned, besides many others interested in the particular work that is going on. These Committees will report on new developments, and also assist in obtaining practical papers. They will also nominate one of their members to the Research Committee of the Institute, which will thus consist of seven or eight members. This plan will unquestionably result in more vitality. The Committees, by making their own reports and by securing authors to write papers on new developments, will infinitely broaden the field.

NORTHAMPTON POLYTECHNIC INSTITUTE.—We have received from this institute a copy of the annual volume of announcements, educational and social, for the session 1916-17, with a notification that in view of the continuance of the war, and the consequent absence of many students at the front or on special war or munitions service, the governing body of the Polytechnic has decided to suspend the usual annual issue of the announcements, but is prepared to start and carry through in the session 1916-1917 as many of the courses and classes announced for the preceding session as may be justified by the applications for enrolment received at the commencement of the session. The address of the Institute is St. John Street, London, E.C.

VANADIUM CASTINGS FOR LOCOMOTIVES.—The use of alloy steel castings for locomotive construction has been rapidly growing for some time. Years ago, before new welding processes were introduced, the breaking of a locomotive frame was a serious matter. Even now, when by means of modern welding devices ordinary breaks are repaired in less than 48 hours, a frame failure is a feature of locomotive maintenance which engineers would gladly eliminate. The vanadium casting seems to have minimised this trouble to a great extent. The first frames of this material were cast in 1907 and they are said to be in service at the present time, no failures having occurred during almost 10 years of service. In a survey reported by the American Vanadium Company, Pittsburgh, showing the performance of vanadium frames in use on seven representative railways, it has been found that failures are almost unheard of, even in the most exacting freight service.

Some Properties of Ingots.*

By A. W. and H. Brearley (Sheffield).

Crystalline Structure and its Effects.

When steel, or any other crystalline substance, is cast into a mould the freezing commences from the inner surfaces of the mould, supposing the substance is quite fluid to begin with. Assuming the mould to be made from cast iron, and its cross section a square, then freezing in any plane occurs more rapidly at each of the four corners than elsewhere; and the crystals lying in and about the corners, in consequence of the rapid cooling, are comparatively small ones. Crystals grow also from the sides of the mould, but as their growth sideways is hindered by the adjacent crystals, and their growth forward into the fluid mass is less restrained, they become long and narrow in shape. The crystals growing from any one side of the ingot mould, presuming the interior mass remained fluid, meet crystals growing from the adjacent sides, and a boundary to the cooling effect of each side of the mould is visible on a polished and etched specimen, or on a fractured surface, as junction lines lying diagonally on the square. These remarks are illustrated by Fig. 1 made from a section of a chromium steel ingot.

In the same way from the bottom of the mould, which is assumed to be flat, crystals grow also upwards until they meet those crystals growing from the sides of the lower part of the mould. It is easy to realise that crystals growing thus from a surface at right-angles to the rest would meet obliquely on planes which outline the form of a four-sided pyramid. In the same way the cooling effect of the atmosphere on the free upper surface would cause crystals of the same narrow kind to grow downwards until they also terminated on the surfaces of a four-sided pyramid, assuming, of course, that the fluid material froze quickly and was not disturbed at the upper end by shrinkage

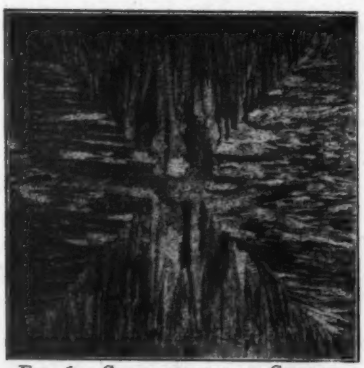


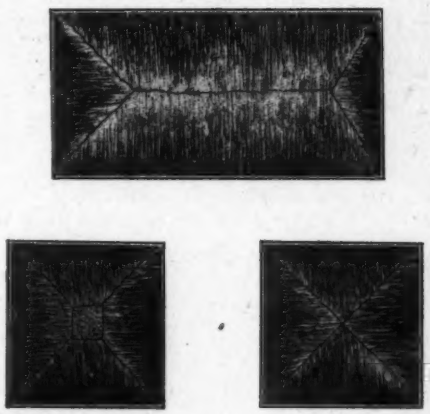
Fig. 1.—Cross-section of Chrome-steel Ingot.

cavities or segregation effects. These considerations enable us to make a sketch diagram illustrating the arrangement of crystals as seen in any longitudinal section cut axially and parallel to a side of the mould (Fig. 2, *a*); in a cross section cut at right-angles to the axis of the ingot, near the bottom (Fig. 2, *b*); and in a similar section cut nearer the middle of the ingot (Fig. 2, *c*).

* Read before the Iron and Steel Institute, September, 1916.

The diagonal lines in Figs. 1 and 2 are lines of extreme weakness; partly because they are lines of contact between crystals growing in different directions to each other, and partly because they are coincident with the intersection of the plane surfaces in the ingot which at successive moments

a



b *c*

Fig. 2.—Diagram of Crystal Growth in Ingots.

were the last to solidify; consequently the planes are rich in segregates and non-metallic impurities (if such, as in steel, can possibly form), they are likely to be occupied by elongated gas cavities, and are also in the position where small cavities caused by contraction stresses would form. The influence of segregate plus contraction cavities would account for a great deal of the observed weakness along the diagonal planes, and it is not possible, apart from this influence, to determine how much of the observed weakness is due only to the crystalline arrangement.

These general observations can readily be verified and illustrated by means of ingots cast with molten stearine. As we have formed a very high opinion of the use of stearine for this and other similar purposes it is desirable at this stage to refer to the very natural prejudice against applying to steel ingots deductions drawn from the behaviour of stearine. To make experiments with steel is no doubt the most reliable way of learning about the changes which occur during the casting and solidifying of steel ingots; but it entails a costly plant, and molten steel is an expensive material and also dangerous when handled by other than experienced persons. There is also no method of determining the temperature of molten steel with satisfying accuracy, and finally, when ingots are made in the predetermined ways the cutting or breaking of them is both lengthy and costly.

With a few pounds of stearine, a pan of water, a beaker, a Bunsen burner, a few tin moulds, and considerable patience, a great number of observations can be made to illustrate, extend, and also, in some respect, to correct prevailing notions about steel ingots. To increase respect for obser-

vations along these lines and cautious interpretations thereof we need refer only to the very striking operation of removing the base pyramid. Those engaged in making ingots for the manufacture of ordnance are aware that for some years it was usual in many works to cut discs from the ends of ingots or billets, and after polishing to etch them. On many such discs the etching revealed a ring of white spots which were really ferrite areas segregated about slag globules. The nearer the base the disc was cut the larger the ring of white spots, which was quite natural on the assumption that the white spots represented the outline of a section cut through the base pyramid. Though the white ring appeared frequently during the few years such observations were being made, no steel-maker, within our experience, would admit that a well-formed cone, such as could be dislodged from a stearine ingot, could ever exist in a steel ingot. Eventually, however, a steel ingot weighing about 8 cwts. was cast in such a way that it was held fast at each extreme end. When cooled under such conditions the ingot naturally cracked across the weakest part, and produced the cleanly separated cone reproduced in Fig. 3.*

In a round ingot the crystals growing from the bottom of the mould are formed into a cone, and in an octagon ingot they form an eight-sided pyramid. In each case the base pyramid is longer or shorter, depending on the cooling effect of the bottom in relation to the cooling effect of the sides; but generally the base exerts its full effect, because it remains throughout in direct contact with the freezing ingot, whereas the sides of the ingot, soon after solidifying, leave the mould and are thereby partly insulated from its cooling effect by a gaseous envelope. In many cases the pyramid may be separated intact from stearine ingots by pressing a knife into the ingot at right-angles to its axis, and splitting layer after layer of the crystals until the peak and ultimately the entire pyramid is disclosed. It is instructive by similar means to take ingots to pieces, as it were, in order to observe the effects of segregation and shrinkage cavities localised on their interior surface.

FIG. 3. — EXPOSED PYRAMID IN BASE OF STEEL INGOT.

The growth of the elongated crystals originating at the surface of an ingot mould depends on circumstances, which appear to be somewhat contradictory, *i.e.*, they are favoured sometimes by slow cooling and sometimes by rapid cooling. So long as the fluid in the interior of the partly solidified ingot remains quite liquid, the crystals already growing from the sides of the mould increase in length as the temperature of the liquid about their extreme ends falls to freezing point. The act of freezing liberates heat, which is either stored up in the fluid or dissipated *via* the solid crystals, through the sides of the ingot mould. If the crystals are bad conductors of heat the cooling is necessarily slow, whatever the properties of the ingot mould may be, and the fluid in the centre of the ingot remains clear almost to the last drop, whilst needle-like crystals extend to the centre.

But if the crystals themselves are good conductors of heat, then the heat liberated as they form and also the heat from the fluid interior is rapidly dissipated through them. In this way the temperature of a large volume of fluid may reach its freezing point in many places simultaneously, before the crystals growing from the sides can extend to the centre, and thus the interior of an ingot would consist of crystals which had grown from independent centres, and were developed in haphazard ways in all directions.

Of crystallisable substances, therefore, which are clearly liquid when cast, those that are very poor conductors of heat will form crystals of the same kind from the surface inwards if allowed to cool undisturbed. But steel, on the other hand, which is a good conductor of heat, will form crystals of the same kind from the surface to the centre of the ingot only if the cooling takes place very quickly or very slowly. In the former case the crystals grow into the clear liquid and extend themselves rapidly as its temperature falls to freezing point; the result being thin crystals like those seen in Fig. 1. In the latter case, however, the cooling is so slow that, owing to its high thermal conductivity, the temperature of the fluid mass becomes practically uniform throughout, and then a crystal is as likely to start growing in one place as in another, the result being irregular and approximately equiaxial crystals.

The considerations in these last two paragraphs are closely bound up with the question of casting temperatures, which will be discussed later. But meanwhile it may be said that the elongated crystals occur most frequently in steel cast in chill moulds of narrow section, and the equiaxial crystals in steel cast in dry sand moulds. Obviously there exists a great number of instances where both kinds of crystals occur in the same ingot, the exterior crystals being needle-shaped and the interior equiaxial.

Shrinkage and Contraction Cavities.

If we imagine an ingot mould filled with fluid material that could be cooled with perfect uniformity down to its freezing point, we should find that the level of the fluid would gradually sink as the fluid cooled and shrank. If at this point the fluid were to solidify instantaneously without change of volume we should have a solid ingot. But neither stearine nor steel behave in this manner, and cavities due both to shrinkage of the fluid and contraction of the solid materials exert a great influence on the economic production of ingots, and have to be reckoned with.

An ingot just cast consists of a thin layer of solid metal with a fluid interior whose temperature we may assume is practically the casting temperature. The outside length of the ingot has been fixed by the thin solid envelope extending downwards from the highest level of the molten metal in the mould. After a little while the solid envelope has thickened, say, by a millimetre, but before that occurs the fluid metal has cooled, and owing to shrinkage does not now stand at the same level. This has been represented in Fig. 4 by a step down between the first and second millimetre in thickness of the freezing envelope. This process may be thought of as repeating itself in successive and distinct stages as long as any fluid remains in the interior of the ingot, and as a re-

* This experiment was made at the works of Messrs. Thomas Firth & Sons, Limited.

sult the central cavity or pipe would be as represented in Fig. 4. As a matter of fact Fig. 4 does represent the general outline of all central pipes in ingots cast in moulds having parallel sides. It

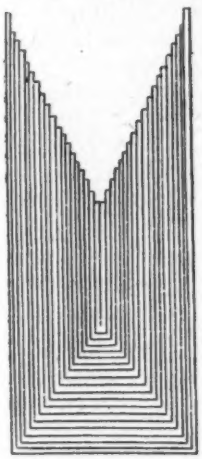


FIG. 4. — DIAGRAM TO ILLUSTRATE FREEZING OF INGOT IN STRAIGHT-SIDED MOULD.

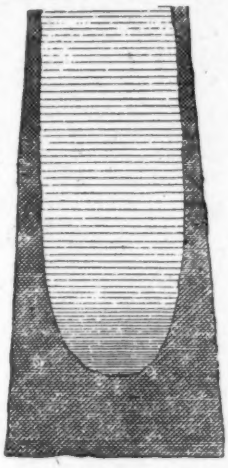


FIG. 5.—USUAL REPRESENTATION OF A FREEZING INGOT.

differs from an actual pipe only because the thickening of the solid envelope is a continuous process and not an intermittent one; and also because the contraction of the solid envelope and the cooling effect of the atmosphere on the upper surface of the ingot must be taken into account.

That the freezing of an ingot takes place by a continuous thickening of the solid envelope in planes parallel to the cooling surfaces of the solid is not unanimously admitted. The illustration given in Fig. 5 has been reproduced and approved as a representation of the freezing of steel ingots. It is, however, so far as the authors' observations go, a misleading representation of steel ingots and an inaccurate representation of the freezing of any crystalline substance, metallic or otherwise.

If a series of stearine ingots are cast simultaneously from, say, 65 deg. C. in square moulds, in all respects identical and widely spaced apart so that each cools freely, then on piercing the top and inverting one of them after fifteen minutes and a further one after each additional fifteen minutes, we are left with a series of shells of gradually increasing thickness, but in each case the shape of the cavity out of which the fluid wax was emptied corresponds to that made by the inner walls of the mould.

The same fact can be demonstrated in a more elegant manner by gradually planing down a single ingot parallel to one of its faces. After a few strokes with the plane the sectional surface exhibits an envelope lying around it. The thickness of the envelope increases as the planing proceeds just as it did when the ingot was freezing, but it remains quite symmetrical in all parts, as may be seen from the series of photographs reproduced in Fig. 6. Also it thickens parallel to the cooling surfaces and forms where the bottom and sides intersect a sharp corner, and not the conventional curve seen in Fig. 5.

That steel behaves in a precisely similar manner is known to those furnacemen who have opportunities now and again of seeing ingots broken up that have been upset or otherwise accidentally and completely bled. By way of illustration some photographs are shown in Fig. 7, representing a crucible steel ingot that was intentionally inverted,

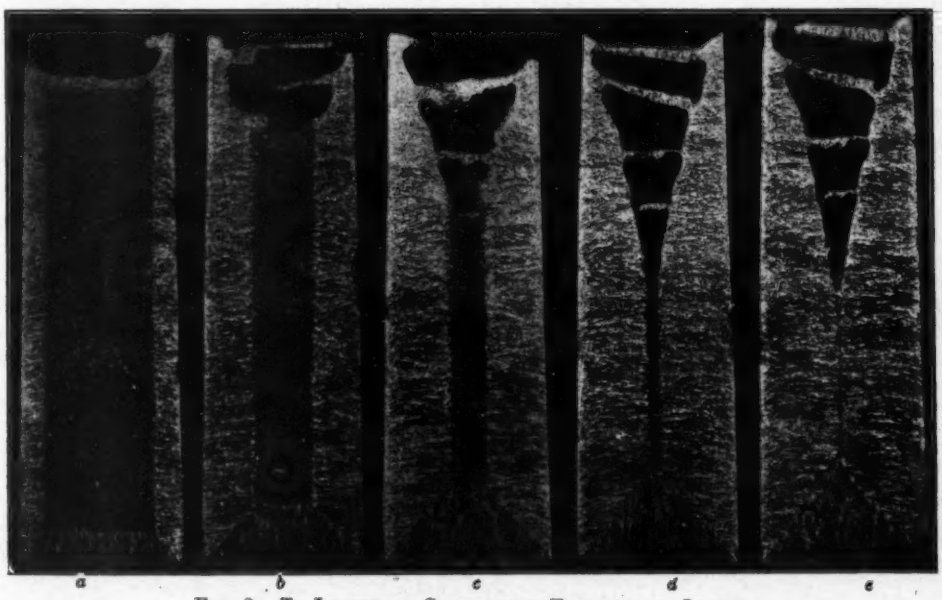


FIG. 6.—TO ILLUSTRATE SYMMETRICAL FREEZING OF INGOTS.

and Fig. 8, which represents one much larger ingot from a series prepared by Talbot.* When freezing takes place in the interior of the fluid

* *Journal of the Iron and Steel Institute*, 1913, No. I., p. 30

mass, and not merely by direct thickening of the walls, the preceding conditions do not apply.

The influence exerted by size and shape of ingot moulds on the position and dimensions of the pipe will be discussed later, but it is desirable at this stage to consider a feature exhibited by many ingots cast in straight-sided moulds as distinct from taper moulds used with either the narrow or wide end up.

When sufficiently removed from the cooling influence of the closed bottom and the open top of

FIG. 7. — PARTLY FLUID CRUCIBLE INGOT INTENTIONALLY INVERTED.

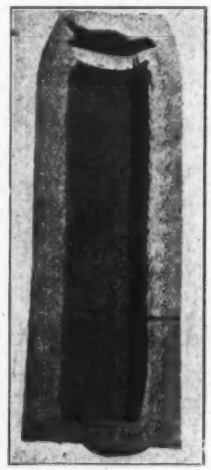


FIG. 8. — OPEN-HEARTH INGOT INTENTIONALLY BLED.

an ingot mould the freezing of any horizontal section of the fluid ingot may be regarded as due to loss of heat through the sides of the mould. When the mould has the same cross-sectional dimensions from top to bottom, the crystals growing from the sides in any one plane are as likely to meet in the centre as soon as those growing in any other plane. Now in both commercial stearine wax and in steel a plane of the material may be all but rigid, quite too rigid at the centre to flow downwards, but requiring still to contract over its entire area. The material next the ingot mould is coldest and most rigid, and if the unavoidable contraction cannot pull the flat outer surfaces inwards, the assumed plane must split at the centre where the material, all but set, offers little resistance. The result is a small central cavity with no material above it fluid enough to flow downwards, and the net effect in an ingot of this kind is a number of cavities roughly spherical in shape, lying in the axis of the ingot. For shrinkage or contraction cavities of this kind an increased length or breadth of feeder head is a doubtful remedy, as in actual practice such cavities occur always in small crucible ingots cast into straight-sided moulds and fed by means of a hot dozzle.

To these two kinds of cavities, viz., the pipe proper and a continuation of the pipe that exhibits itself as a kind of axial sponginess, which, when elongated, may be regarded as a secondary pipe, we must add also cavities, axial or otherwise, arising from the contraction of the hot solid ingot. Such cavities may occur in ingots independent of their shape, and should perhaps be described as contraction rather than shrinkage cavities.

An ingot which has quite set and is still hot contracts in volume on cooling, but as the outer surface of the ingot is hard, and will not yield much, the stress of contraction will be satisfied, wholly or partly, by the formation of internal cracks or cavities in those positions where the resistance is least. In a solid ingot there are certain planes of weakness, due to the arrangement of crystals, which converge from the corners of the mould towards the axis of the ingot. An ingot is therefore easily split along its axis by tensional forces acting at right-angles to its length; and it is further induced to yield to such forces by the fact that the ingot is hotter in the centre and weaker also on that account.

This explanation accounts equally well for axial cavities and cracks formed just before or just after complete solidification. As, however, the contraction of the hot solid material takes place continuously in those parts of the ingot already solidified, and does not wait until the entire ingot becomes solid, we may expect to find contraction cavities which were formed whilst the centre of the ingot was still fluid, and in that case they would not, of course, be formed at the centre.

From the moment that a solid envelope is formed about the liquid the crystals growing from the sides of the mould form planes of weakness where they meet each other obliquely, and it is along these planes that contraction cavities are located. They are easily seen when a stearine ingot, cast under favourable conditions, is split diagonally along its length, and may be reproduced photographically as in Fig. 9, after planing an ingot down until a diagonal section is exposed. These cavities all converge to the centre of the ingot, and appear to depend on and originate from an axial cavity. That they are not developed in that order, but begin to form whilst the centre of the ingot is quite fluid, could be shown by bleeding partly frozen ingots and bisecting the solidified shell diagonally.

FIG. 9.—DIAGONAL CONTRACTION CAVITIES.

There are several reasons why contraction cavities should lie along these planes, extending from the corners to the centre of a square ingot. In the first place the planes are formed by the intersection of surfaces of the ingot which at successive moments were the last to solidify; and about the angle thus formed the contraction stresses are localised with the consequent danger so often exhibited in the hardening of steel tools cut with sharp corners for keyways, etc. Then any absorbed gases liberated at the moment of setting and impurities likely to segregate are also to be found in abnormal amounts along these planes. It needs therefore nothing but a favourable concourse of circumstances to produce large cavities or even extended cracks; and in average cases it needs very little force in addition to the ordinary contraction stresses to cause rupture.

But in addition to cavities that are obvious to the naked eye it is not unusual in steel ingots to find cracks running betweeen the crystals at right-

angles to the surfaces of the ingot mould. These cracks are discoverable by direct microscopic observation as in Fig. 10, which is an enlargement of part of Fig. 1.; or indirectly by making use of corrosion effects.

Cracks may be revealed in large numbers by immersing a disc of steel in a 10 per cent. solution of hydrochloric acid. The acid attacks the metal most vigorously along the edges of any existing cracks, and eventually the crack widens into a visible cavity. This effect is shown in Fig. 11, which represents a disc cut from a 4-in. square ingot; it will be noted that the length of the cavities lie in the same direction as the length of the crystals between which they occur. Cavities of a similar kind which originate from segregated areas may also be developed by extended pickling; but there are decisive means of distinguishing one kind from the other, and confusion is not likely to arise if careful observation be made of the scattered distribution of the former compared with the occurrence in groups of the latter.

Radial cracks may occur in steel ingots which do not exhibit elongated crystals on a fractured surface. When a disc cut from a large steel ingot weighing, say, 40 or 60 tons, or from a circular billet which has been forged from such an ingot, is polished and etched with a very dilute solution of nitric acid in alcohol, the intercrystalline cracks

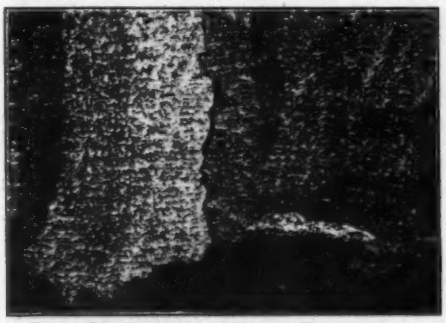


FIG. 10.—PORTION OF FIG. 1 ENLARGED TO SHOW CRACK BETWEEN CRYSTALS.

are located by the evolution from them of small gaseous bubbles. That the gaseous bubbles may escape more easily it is advisable to arrange the disc with the polished face in a vertical position and wash it over by means of a broad camel-hair brush with the etching fluid; small strings of bubbles then run with the solution down the face of the disc from one or two or maybe a score or more cracks. The objectionable features of contraction cracks are emphasised by segregation or slag occlusions, and these as well as the amount of hot work done in the forging determine whether or not the crack will weld up.

If the material in which the cracks appear is not weldable, then it is also not forgeable, and will crumble under the hammer. This explains why some alloy steel ingots may not be forged, whereas others of the same composition, but melted and cast under different conditions, forge fairly well. The number and magnitude of the cracks would obviously be increased if the steel had air-hardening properties.

Casting Temperatures.

When a crucible steel ingot breaks with a needle-like fracture (Fig. 2, *c*) it is said to be "scorched," and scorching is said to be due to the molten steel having "had too much fire." A furnaceman does not generally commit himself by saying whether the steel has been for too long a time in the furnace or at too high a temperature. He may not know;* but he does know a scorched ingot can be broken across with remarkable ease, and that he will very likely get into trouble if he makes many such ingots.

Scorched ingots are objectionable only on account of their fragility, due to arrangement of the crystals in definite directions, and the extended contraction cavities which may arise. This is, of course, a serious objection, because unless the scorched ingot, after reheating, is very carefully, and, to begin with, very gently forged, the weakness between the well-developed crystals will cause cracks to form at the corners of the forged bar. But apart from obvious defects like this, the quality of the steel is neither better nor worse for having shown the scorched appearance in the ingot.

The characteristic appearance of both the inside and outside of "cold cast" ingots is understandable after seeing a stearine ingot cast into a glass mould. First as to the outside. As the wax, per assumption, has already reached its freezing temperature it solidifies immediately on contact with the bottom and sides of the mould. It freezes also over the free upper surface into a crust of crystals, and as more fluid wax is added the liquid level and

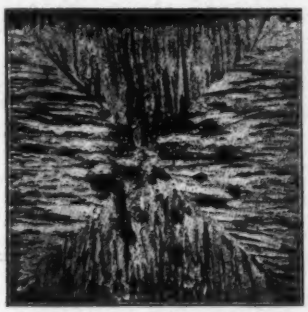


FIG. 11.—CRACKED SURFACES CORRODED BY PICKLING.

solid crust rise together, the latter generally increasing in thickness. But the crystal crust has solidified into a piece with the sides of the ingot, and as the fluid wax rises it pushes the crust upwards most effectively where it is least restricted, *i.e.*, in the centre. The crust therefore becomes increasingly convex until, broken by upward pressure of the fluid wax, a new surface is formed. In the act of forming a new surface the fluid wax strikes the glass mould and is frozen before it can fill up the lowest part of the convexity, and hence the surface of the stripped ingot is a series of rings where it has been in contact with the mould, and a series of depressions lying alternately between them where it has not been in contact with the mould. (Fig. 12.)

Pieces of broken crystalline crust are washed into the fluid material, and form independent centres of crystallisation in both stearine and steel. But in steel they may also form blowholes, due to a gas liberation promoted by their oxidised surfaces, and also irregular lines of weakness which may not weld up completely in the subsequent forging.

The internal structure of a "cold cast" ingot is

* Text-books say: "If kept too long in the furnace the steel will teem dead, and the fracture of the ingot will have what is known as a 'scorched look'" This is misleading.

unlike that of a "hot cast" ingot, because in the former case the centres of crystallisation are dispersed throughout the entire ingot instead of being confined to the inner surfaces of the mould or the solid metal envelope already formed from it. The crystals therefore do not grow in planes but in all directions, and form spherical clusters floating in the fluid like seed-pods of a dandelion floating in still air. The clusters of solid crystals are heavier than the fluid steel and tend to sink to the bottom of the mould.

We have said that an ingot freezes by a gradual and uniform thickening of its solid walls in planes approximately parallel to the inner surfaces of the ingot mould (see Fig. 6). But this statement applies only when the conditions are such that the interior fluid is a perfect liquid. If free crystals form in the liquid independent of the cooling effect of the mould they will rise, as in antimony-lead alloys (see Fig. 13), if they are lighter, or sink as in stearine and steel if they are heavier than the mother liquid. In the latter case the base of the ingot will be thicker, at any moment during solidification, than can be accounted for by direct cooling effects in those positions.

The presence of separated crystals in stearine ingots can be demonstrated in two or three ways. One way consists of emptying out the fluid portion either by inverting the ingot or by passing a hot rod through the base of the ingot. By the first-named procedure the crystal groups are disturbed, and by the last-named procedure some of the fluid solidifies in passing through the thick cooler base of the ingot. But in either case the information sought can be easily interpreted apart from these interferences, as may be seen by reference to Fig. 14, which represents wax ingots cast from 55 deg. C., and bled through the top end after varying lengths of time.

The formation of free crystals in the fluid material adds considerably to the mechanical strength of an ingot by interfering with the growth of elongated crystals at right-angles to the sides of the ingot mould, *i.e.*, by suppressing the scorched appearance. This is apparent in stearine ingots on attempting to split them diagonally, and particularly in attempting to remove the base pyramid as previously described. It is apparent also in small steel ingots by the greater effort required to top them. In large steel ingots the formation of free crystals is also made apparent by the very marked difference in carbon content between the top and bottom of the ingot—in fact, it is impossible to cast a very large ingot of, say, 40 tons or over from the same ladle and maintain, apart from localised segregation, a uniform amount of carbon throughout its length. The steelmaker has therefore to compromise between two evils, *i.e.*, he may either cast hot and emphasise local segregations, shrinkage cavities, and contraction cracks, or cast cold and widen the difference in composition between the top and bottom of the ingot. The crystals first formed in fluid steel contain, of course, less carbon than the remaining mother liquid, and this explains why the settling of the crystals to the bottom of the ingot widens the variation in composition.

To express in definite figures the influence of varied casting temperature on the mechanical properties of steel would involve an enormous amount of labour and require great experimental skill. It would, for example, not suffice to machine test-pieces out of an ingot, because the defects to be looked for would sometimes be in the test-piece and at other times not; and even if it were practicable to machine always a test-piece containing a typical defect, it would be quite impossible to arrange for the defect to occupy the same relative position in every test-piece, and therefore the tensile properties of the test-pieces would vary amongst themselves without indicating any corresponding variation in the ingots from which they had been prepared.

The least objectionable form of test-piece is the ingot itself. But as commercial ingots are not amenable to the requirements of testing methods and machines, and as, further, there is no handy means whereby the casting temperature of steel can be accurately measured, we are obliged to content ourselves with general statements to the effect that the casting temperature of steel may be too high or too low to produce the best results. When it is

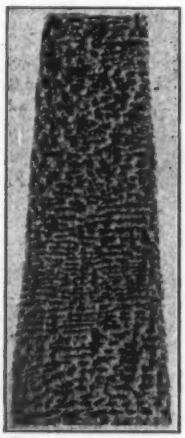


FIG. 12.—APPEARANCE OF SURFACE OF "COLD CAST" INGOT.

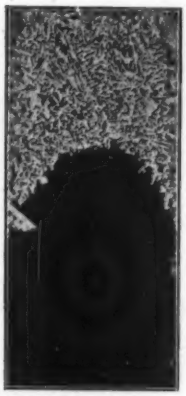
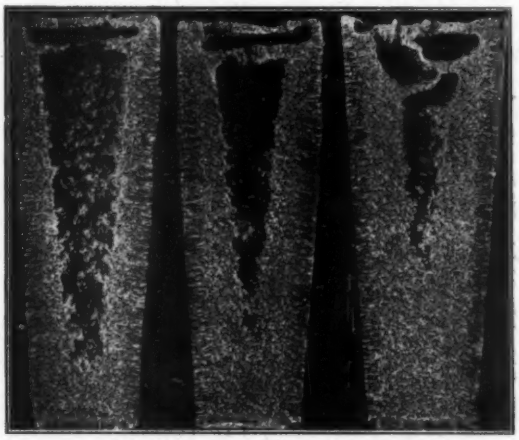


FIG. 13.—ANTIMONY CRYSTALS FLOATED TO SURFACE OF PARTLY SOLIDIFIED ALLOY.



a b c

FIG. 14.—CRYSTALS DEPOSITED FROM PARTLY-SOLIDIFIED INGOT ON BASE AND SIDES.

remembered that the correct, i.e., the best casting temperature differs from one material to another, and for the same material according to the weight and dimensions of the ingots, to say nothing of foundry castings, there appears to be ample room for the exercise of the art as distinguished from the science of steelmaking.

But in making wax ingots the variable conditions are controllable with that degree of accuracy which yields confirmatory results from duplicated tests, and as the behaviour of stearine wax in so many respects is comparable to the behaviour of steel, it may be possible by its aid to confirm the general statements alluded to in the preceding paragraph, and also, by analogies carefully drawn, to add something to it.

Apparently the least troublesome way of casting a series of ingots from varying temperatures is to melt a large beakerful of stearine and cast one ingot after another as its temperature falls. But the application of this method leads to very erratic results, because, in passing over the colder lip of the beaker, the wax solidifies and, in the worst cases, small pieces of solid wax are carried forward into the ingot. These are comparatively harmless when the temperature of the cast ingot is sufficiently high to remelt them, but otherwise they

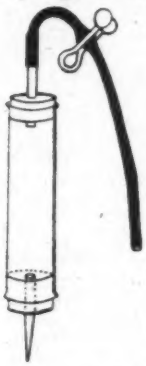


FIG. 15. — ARRANGEMENT FOR CASTING WAX TEST INGOTS.

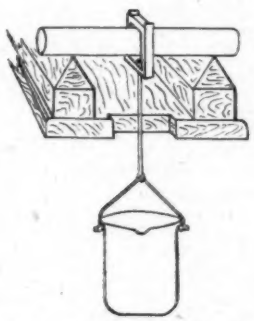


FIG. 16.—ARRANGEMENT FOR TESTING STRENGTH OF WAX INGOTS.

cause what should be a scorched ingot to appear granular or finely crystalline on its fractured surface.

To avoid this irregularity use may be made of glass tubes, 7 in. long by ¾ in. in diameter, which have at each end a well-fitting perforated cork. Pieces of thin glass tubing fit into the corks, the one at the lower end being drawn out to a fairly fine point, and the one at the upper end being provided with a few inches of rubber tubing and a spring clip (see Fig. 15).

The lower drawn out end of the glass tubing is kept at the temperature fixed for the ingot next to be cast, so that when immersed in the fluid wax the opening is not stopped up. The molten wax is drawn upwards by suction on the rubber tube until the mould is nearly full. The pinch-cock is then closed; the end of the lower projection is dipped into cold water to solidify the wax and so close the opening; the upper cork, together with the rubber tubing and pinch-cock, are removed, and the mould is allowed to stand quietly in a vertical position until it becomes quite cold. Series of ingots are made successively in this way as the temperature of the melted wax sinks; and it is easy to arrange for the temperature to fall at the rate of, say, 1 deg. C. in fifteen minutes, thus permitting duplicate or triplicate ingots to be made at each chosen temperature.

The simple piece of apparatus shown in Fig. 16 may be used to test the strength of the ingots made as described. The ingots rest on supports 4 in. apart, and midway between the supports a pan is hung into which mercury is allowed to flow from a graduated burette, or into which small leaden shot is poured until the ingot breaks. The burette is then read off or the weight of shot used is noted in order to arrive at the breaking load in grammes. As the results are merely comparative the net breaking loads on the ¾-in. circular ingots used are given in Table I.

The most noticeable feature in this series of results is the great increase in strength between those ingots cast respectively at 56 deg. and 54 deg. C., the latter being almost twice as strong, and this is confirmed by the appearance of the fractures, which show a marked difference within this short range of casting temperature. The ingots cast at 54 deg. C. have a granular or finely crystalline structure, whilst those cast at 56 deg. C. and over show scorch. This observation is quite in line with the behaviour of small steel ingots, both as regards appearance of fractured surfaces and mechanical strength.

TABLE I.

Casting temperature. Deg. C.	Breaking load in grammes.					
	1.	2.	3.	4.	5	Average.
80	1,618	—	—	—	—	—
75	1,671	—	—	—	—	—
70	1,551	—	—	—	—	—
65	1,220	—	—	—	—	—
64	1,292	1,155	1,208	—	—	1,218
62	1,048	1,009	—	—	—	1,029
60	1,224	1,274	1,168	—	—	1,222
58	982	1,009	1,088	—	—	1,026
56	1,459	1,155	1,605	1,830	—	1,512
54	2,783	2,995	2,783	3,193	3,127	2,938

	Grammes.
One minute after reaching 54° C	3,250
Two " " "	3,224
Three " " "	3,021
Four " " "	2,995
Five " " "	3,101
Six " " "	2,929

The increase in strength when the casting temperature reaches 65 deg. C. is also notable and not especially difficult to understand. It is to be expected that, all other conditions being equal, a rise in the casting temperature alone would cause the ingots to become gradually weaker, but a rise in casting temperature disturbs the other conditions, and more especially the rate of cooling, so that an ingot cast with wax at 58 deg. C. into a thin mould might at once have a solid envelope formed around it by the cooling action of the mould; whereas when cast from a higher temperature the heat lost in cooling the mould might depress the temperature of the fluid wax to 58 deg. C. without causing a solid envelope to form around it. The rate of cooling in the two cases would then vary, and the latter would be more or less disposed to form the stronger equiaxial crystals depending on the thermal conductivity, specific heat and mass of the ingot mould, and on the relative thermal conductivity of the fluid and solid ingot material. It is therefore likely that at some temperature well above the freezing temperature a wax ingot or a steel casting would become stronger, but the rise in strength would not occur at the same temperature of course except under identical experimental conditions.

(To be continued.)

Influence of Gating on Castings.

Symposium Presented at the American Foundrymen's Conference.

GATING GREY-IRON CASTINGS.

By B. D. Fuller, Cleveland.

Founders are well aware that it is expedient in some cases to have a number of small gates or entrances whereby the inflow of metal to the mould can be checked and the dross collected. Again there are cases where it is best to open the flood gates and have the filling over as soon as possible. Then there are times when a casting may be gated to fill either slowly or rapidly.

There is nothing about the moulder's work requiring more consideration. Imagine a frame filled by a light matting or grating. To gate this on the outer edge of the frame would add the weight of the gate in a place where already is too much weight in comparison to the centre. Also the hotter iron would remain in the frame or heavier part and, as the centre cools first, the shrinkage of the frame would take place after the light centre had set, causing distortion or cracking. Such a casting should be poured through flat gates set across the light checkered centres, introducing the hotter iron and added weight where it is needed.

A case where just the opposite method has proved the better, is that of a light cup-shaped industrial motor frame. Imagine the rim or lip of the cup to be machined to receive the bracket. Five holes are drilled in spots close to the edge of the rim. Gating this in one spot on the circumference causes a hard spot where the flow of iron meets just opposite the gate and difficulty is encountered at this point when machining or drilling is attempted. A gate provided with a channel extending entirely around the casting with a number of sprues leading from the channel to the circumference of casting, will distribute the iron more equally and hard spots will be avoided.

The Horn Gate.

Another very successful form of gating is the well-known horn gate. When casting brackets with heavy hubs and light frames similar in shape to an ordinary wagon wheel, with the hub quite heavy in proportion to rim, ordinarily the casting would be gated on the rim; but by running the gate under the rim and into the bottom of the hub, allowing this part to fill first and the iron to spread out evenly from the centre a better casting results.

The system used with multiple moulds (one casting on top of another, six or seven high, each being provided with its own gate) is very satisfactory in casting deep moulds. For instance, consider a turbo-generator frame, which may be 15 or 16 ft. in diameter with a 9 to 10-ft. face, cast on its side and is cored out intricately. The gate in this case first receives the iron at the bottom of the mould, and after the cavity is partly filled, the pressure on the bottom gate increases, causing the flow to be checked and the next sprue above to do its share of the work. This sprue, which is inclined from the down-gate to the casting, continues to handle the flow until a certain elevation has been attained by the rising metal, when the next sprue in turn takes up the work. Two or more down gates, for double pouring, generally are used.

In connection with this sort of work a brick runner, which may be made in sections that fit one into the other to any desired height, will be found excellent. It is not possible, where these runners are used properly, to have a gate strain or cut. Strained or cut gates are the cause of many lost castings. A large pouring basin should be used in connection with the brick runner. A basin holding as much as an ordinary wash tub usually will be found satisfactory. It is generally best to have the down-gate, built of brick runners, extending like the neck of a funnel directly from the bottom of the pouring basin, and to plug the top of the down-gate with a cast tapered plug provided with an iron handle extending above the basin. This plug will represent the ferrule upon a cane, the handle being above the rim of the basin. When pouring, the plug is not removed until the basin is full, which ensures only clean iron entering the gate, as the slag will float on top of the metal in the basin.

Inclined Moulds.

In some examples, such as large flat plates, it is better to incline the mould, pouring from the lower point and forcing the iron gradually uphill. When poured flat it will flow around in a thin body until it meets at a given point with a sort of seam, any foreign matter which may be on the face being picked up and carried to this meeting point. It is to avoid this that the mould is inclined.

As mentioned previously it is sometimes better to pour the entire amount of metal into the mould at one time. An example of this is found in a mechanical casting process used in making pipe-shaped rolls, packing rings and similar castings. The mould, which is of metal, is revolved at a high rate of speed. The iron is introduced while the mould is revolving. The proper distribution is accomplished by the centrifugal force of the rapidly revolving mould.

There is a wide field for ingenuity in gating moulding-machine work, particularly the lighter castings such as are made in snap-moulds from metal patterns. For general utility in this class of work, the saw-tooth skimmer is excellent both on account of its simplicity and its efficiency. A stick of any desired length with saw teeth cut in one side will do the work. For ordinary use the stick, or gate, should be approximately $\frac{1}{2}$ by $\frac{3}{8}$ by $\frac{3}{4}$ in. It should be placed in the mould with the teeth in the cope, so that the iron will flow against them on its way from the sprue to the mould. The teeth will collect and hold the dirt.

GATING MALLEABLE-IRON CASTINGS.

By A. M. Fulton, Pittsburgh.

The correct gating of a malleable iron casting is just as important as a proper mixture of iron, and should have as much thought devoted to it as to any other feature connected with making the mould or pouring the metal. Irregular sections and sections joining at right angles prevail to a large extent in malleable castings used in railroad car and heavy construction work. This condition causes an unequal cooling which creates shrinkage and checks at the heavy or adjoining sections.

Many patterns are condemned if the loss of castings is above normal and the trouble is attributed to the design, when it should have been charged against the gating. The points to be determined are:—(1) Can the casting be fed from the proposed gate, excluding slag and preventing misruns? (2) Should the heavy or unequal part be fed with a riser located at the top of the casting as shown at Nos. 1 and 2, Fig. 1, or adjoining the heavy section as shown at No. 3, with a gate into a lighter part of the casting where the likelihood of shrinkage would not occur?

Also there are designs in which the shrinkage can best be taken care of by the use of chillers. If it is possible to eliminate chillers entirely, it is better practice to do so, as a shrink-head prevents any possible void, while the chiller simply drives the shrinkage to a part of the casting where it possibly may do no harm. The use of properly proportioned heads correctly located will yield much better results than can be obtained from chillers, and while the remelt will be increased somewhat, nevertheless, satisfactory castings are secured, providing a correct mixture has been used. All shrinkage is absolutely eliminated and there is no fear of "too hot iron" when heads are substituted for chillers.

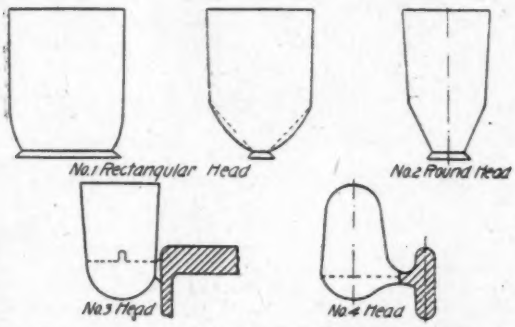


FIG. 1.—DIAGRAM SHOWING DIFFERENT TYPES OF HEADS.

After tentative plans for gating are settled and moulding has been started, it sometimes happens that trouble again arises, in which event the foundry foreman must alter his arrangements. A miscalculation may have been made in the location of the gate, or again, it may have been too heavy at the entrance into the casting. Should the former be the case, then a study should be made of the best point to re-locate the gate, having in mind the two suggestions made in a preceding paragraph.

In cases where a large number of small patterns are gated together to make as large a mould as possible, due to the light weight of the castings, one must not lose sight of the fact that it is important to cast each piece successfully. If too many patterns are gated together, or if they are not arranged correctly, and some pieces misrun or shrink, it is necessary to think out the best method of changing the gate or decreasing the number of patterns to overcome this trouble.

Should the castings contain shrinkage defects in cases where the engineer who made the design based his calculations on solid sections, he certainly would be disappointed, as he would not secure the strength counted upon throughout the entire casting. A number of diagrams, Fig. 1, are presented showing different designs for heads. A few illustrations of castings, with the gates and heads intact as they came from the sand, also are presented, no attempt being made to show anything special.

In locating a head to feed a casting adequately, it should be placed at a point where the weight of the metal will feed down into the casting, as otherwise the head might rob the casting it was supposed to feed and thus cause shrinkage. In a case of this kind, the head usually should be placed over the heavy section and the gate located at a point where the section is more uniform. For instance, on a flat surface, the use of a design similar to No. 1 or No. 2, Fig. 1 should produce desired results. Should the design of a casting be similar to No. 3, which is a very unequal section, a head of the shape illustrated should feed the casting uniformly. The basin shown below the dotted line keeps the metal in the gate hot and fluid and prevents any possibility of chilling at this point, which would retard the feeding effect. With a section similar to No. 4, Fig. 1, a feed-ball with a basin is satisfactory and in such cases proves very effective in eliminating shrinkage.

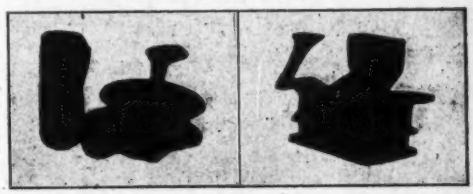


FIG. 2.—A MALLEABLE IRON SHEAVE-WHEEL OF IRREGULAR SECTION.

FIG. 3.—SIDE-BEARING SHOWING HEAD USED TO ELIMINATE CHILLERS.

Fig. 2 shows a very irregular sheave wheel casting, in which the sections are far from uniform. The rims are only ¼-in. thick, the flange to which the head is attached, and the centre of the casting range from 5/16 in. to ⅝-in. in thickness. The casting is gated over the centre core with leads sufficiently large to admit the iron freely, yet keeping out the slag. The head in this particular casting is located at the bottom and feeds the casting thoroughly.

The sections in the side-bearing casting shown in Fig. 3 vary from 5/16 in. to ⅝ in. There are a large number of angles giving excellent opportunities for shrinkage. Originally this shrinkage was taken care of by chillers placed in the corners. These chills were eliminated when the head was substituted, and an absolutely solid casting was the result. The head is so proportioned that the weight of the metal feeds down into the casting.

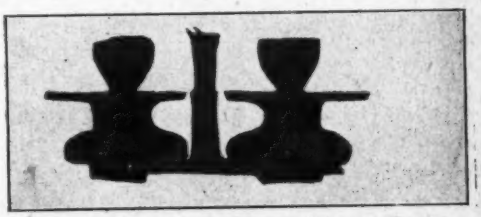


FIG. 4.—HINGE-BUTTS WITH HEAVY HEADS.

The hinge butt, shown in Fig. 4, is of ½-in. section except at the location of the gate, where it is approximately 1 in. There is a round head located on each casting which feeds down through the centre web, eliminating all shrinkage.

The back-stop shown in Fig. 5 is of ¾-in. section throughout, with a centrally located web. The construction is such that the centre web is pulling against the outside walls during the cooling period. This unequal cooling is compensated for by the head shown in Fig. 5. This head has proved very effective.

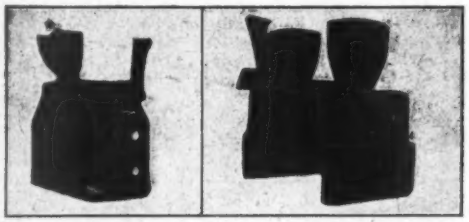


FIG. 5.—BACK-STOP WITH A TROUBLESOME WEB.

FIG. 6. — CENTRE-SILL SEPARATOR FROM WHICH CHILLERS WERE ELIMINATED.

In the centre-sill separator shown in Fig. 6 the metal thicknesses vary from ½ to 1 in. At one time this casting was made with chillers located around the centre web, the metal being poured from the same gate, as now shown in the photograph. The shrinkage was completely removed in this casting by changing from the use of chillers to heads.

The column-post, Fig. 7, is gated on the side opposite from that shown in the illustration with

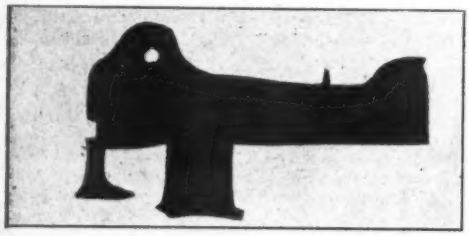


FIG. 7.—COLUMN-POST GATED ON THE SIDE.

four leads into the mould. The head is located on the flat surface and successfully feeds the casting, eliminating all shrinkage.

The design of the cheek-plate shown in Fig. 8 is such that it requires three heads to feed it. Also chillers are located in each of the three slots. Due to the dimensions of these slots and the necessity for the distance between them being exact,

FIG. 8.—CHEEK-PLATE WITH THREE FEEDING HEADS.

it was decided to mould these castings with dry-sand cores in the slots to facilitate the manufacture and reduce variations. The heads feed the casting very successfully.

A bolster-centre filler casting is shown in Fig. 9. This casting is considerably above the average size. The feeding is taken care of by the two heads shown in this illustration. These heads pipe for a considerable depth, which makes it certain that the casting is fed sufficiently.

There are innumerable malleable castings that do not require such measures as have been illustrated in this Paper to ensure soundness, because their sections are both light and regular. Such castings can be made successfully by using the style of gate in vogue for many years.

GATING STEEL CASTINGS.

By W. J. GILMORE, East Chicago, Ind.

To cover the entire subject of various kinds of gating for all work would take a great deal of space. The following data will therefore cover only my experience in gating while using the bottom-pouring type of ladle.

The first point to consider is whether the casting

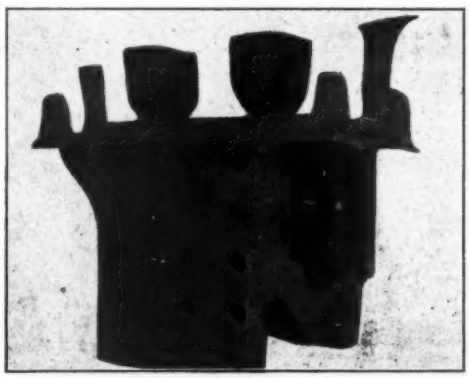


FIG. 9.—HEAVY BOLSTER-CENTRE FILLER CASTING WITH TWO HEADS.

will run with the particular size and style of gate proposed. Secondly, the place of gating should be considered. If gated at a certain point, will the casting check, scab, draw down or make a dirty casting? After due consideration of these points we must not overlook removing the gate from the casting in the cleaning room. On all castings where it is possible to do so, I have found it advisable to use a bottom gate, also known as a fountain gate. This gate causes the metal to flow into the mould more easily on account of the corners it is forced to turn before entering the mould. Then,

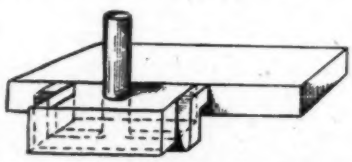


FIG. 10.—CORE GATE SUITABLE FOR SMALL CASTINGS.

too, the area of the gate must be greater where joining the casting that at any other place to be assured of an easy flow into the mould. On castings where it is impossible to use a bottom gate, the core-gate, which answers the same purpose, is used. This gate, which is just as practical as the bottom gate is on larger work, is shown in Fig. 10.

On matched work when rammed on jarring machines where too much time would be lost in cutting a bottom gate or by the use of a horn gate, it is practical to use a core gate, as shown in Fig. 11. When it is necessary to make castings true

to pattern a very good gate to use is the strain gate. This is very similar to the skim gate used extensively in iron foundries. This gate is attached to two centre plates, as shown in Fig. 12.

It is customary in most foundries to use a fillet where the gate is attached to the casting. This is necessary on large castings or castings with heavy sections. In foundries where miscellaneous floor work is made, the moulders cut the fillets

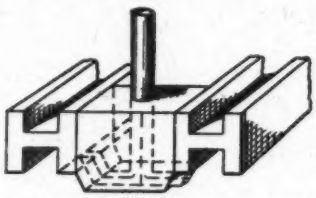


FIG. 11.—CORE GATE SATISFACTORY AS A SUBSTITUTE FOR A BOTTOM GATE.

on the gates. The fillets are often cut too large, which allows the gate to break, leaving a large stub attached to the casting, which is difficult to remove. On small castings I do not think it necessary to use a fillet. If no fillet is used, the gates will be easily broken from the castings and also will break flush with the casting, involving very little grinding.

FIG. 12.—STRAIN GATE USED WHERE CASTINGS MUST BE TRUE TO PATTERN.

To make good, clean steel rolls, a gate must be used that will cause the metal to swirl in the mould. This will keep all sand or dirt washed from gate in the centre of the metal and will carry it up into the head. In this case, the down gate must be of greater area than the gate running from the down gate to the mould proper. The gate entering the mould must be set at the proper angle to make the metal to hit the walls of the mould upon entering, thus causing the metal to swirl.

Gates should never be covered with brick or scrap plate. Brick is not made of the proper material to withstand the molten steel without washing away. Scrap plate will chill the metal and, if rusty, will cause it to blow. Slab cores should be made of a proper size suitable for covering all styles of gates. It should always be remembered that more metal comes in contact with the walls of the gate than with any other part of the mould, and the metal is at a higher temperature when passing through the gate than at any other time. Knowing this, the moulder should protect the gate with the proper mixture of facing and also see that it is rammed correctly.

THE partnership heretofore subsisting between Messrs. F. Fisher and S. Onions, carrying on business as pattern-makers, at 89, Bradford Street, Birmingham, under the style of Fisher & Onions, has been dissolved. The business will be continued by Mr. F. Fisher.

Technical Education in the Iron Trade.

At the British Association's meeting at Newcastle-on-Tyne in September, in the course of the proceedings of Section B (Chemistry) several references were made by DR. STEAD to the question of technical education on the Tyneside. Taking up a point made in the Presidential address to the Section as to the poor remuneration offered to scientific men generally, he recalled an instance of one of his students, before the war, going to a works where a man was wanted to do all the research and analytical work. He asked for £100 per annum, but the works manager was astonished, and said that many men would do it for £50 per annum! Similarly, not so very long ago, he had astonished a meeting of foundrymen when he told them that when they thought more of their scientific advisers than they did of their timekeeper there would be some hope for them. Since that time he was glad to say that the metallurgical adviser was being recognised as even more valuable than the timekeeper, and many works were engaging men of scientific education and attainments for control and organisation in the preparation of metals for casting purposes.

On another occasion, DR. STEAD pointed out how anxious ironmasters were to encourage technical education. A prominent ironmaster had told him he was willing to keep continually three men in his works, selected from the best of the evening-class students, to complete their studies and to pay them £100 per annum each meanwhile. At the same time he (Dr. Stead) expressed the hope that more ironmasters would collaborate with the universities and technical colleges in working the "sandwich" system of technical education, as he preferred this to having small-scale industrial plants, worked more or less under commercial conditions, at the teaching institutions.

PROFESSOR O'SHEA, on the same occasion, viz., a discussion on the training of chemists, said the commercial metallurgical plant at the Sheffield University had been a complete success, as was also that at Birmingham in connection with the production of gaseous fuels. At the same time the "sandwich" system was worked at Sheffield for mining, where, for the diploma course, the student spent six months in the University and six months in a coal mine.

CERIUM PYROPHORIC ALLOY.—The pyrophoric metal used on cigar lighters and for igniters in miners' lamps might be considered as an alloy steel, as it consists substantially of 30 per cent. of iron with 70 per cent. of cerium. It was patented by Welsbach, whose name is identified with the Welsbach light. The striker is of the grade of hardened file steel with about 1.50 per cent. carbon. The detached particles of the cerium-iron alloy take fire in the air, ignition being quickened no doubt by the heat generated in the impact of the striker.

MIDLAND REFRACTORY SANDS.—Before the British Association's meeting, PROFESSOR W. G. FEARNSIDES (University of Sheffield) and DR. P. G. H. BOSWELL (London) described the occurrence of refractory sands and associated materials in a series of large cavities in the limestone rocks of Derbyshire and Staffordshire. They had been investigating in connection with work for the Ministry of Munitions, and found that these hollows contained detrital remains from rocks which once covered the district, but which had since entirely disappeared by denudation. As a matter of fact, these materials had been accidentally preserved, and had proved of the greatest possible economic value, inasmuch as they were far better than the material previously obtained from Germany and the Continent for lining retorts, and could be worked at the surface at a minimum of cost.

A Moulding Shop of the Eighteenth Century.—I.

By Joseph Horner.

The illustrations are those of a moulding shop described in the great French Encyclopedia, of date 1765, with illustrations of the work done. This foundry carries us back to pre-cupola days, for the castings were ran direct from the blast furnace without remelting. But as the iron was smelted with charcoal and with cold blast, the quality of the metal was much superior to that of the iron smelted to-day. The same furnace and the same metal were used to run the long pigs for the refinery, and the metal for the castings. This practice was similar to that adopted at Coalbrookdale at the same period. Fig. 1 gives a general plan of the workshop, with the furnace, and the equipment for the moulding in open sand, and that of the moulding in boxes, the moulding in loam "terre" and the drying.

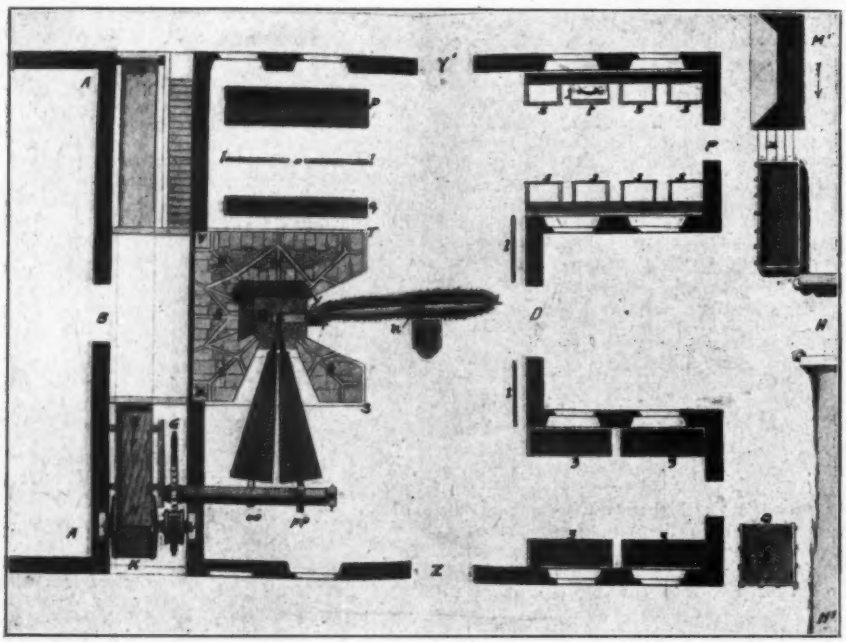


Fig. 1.

In this illustration, *A*,*A* is the charcoal store for the furnace supply. It is raised above the level of the ground in order to be at a convenient height for charging the furnace, being brought nearly level with the charging platform, as seen in the upper part of Fig. 2. There were no hoists in those days. *B* represents the door of the room, there being a staircase for descending from the level of the floor to the bottom of the furnace. This staircase has its origin near the hatch, or sluice, of the watercourse, and terminates at the corner *V* of the masonry. *M*, *N* is the watercourse which furnished the water to the wheel, and *M* is the hatch. The water of the pond arrived at the hatch under one arch, indicated by the dotted lines above *M*. *K* shows the wheel with blades that received the water on top (overshot wheel)—compare with Fig. 2. A lantern wheel communicated the movement to the cog-wheel, G, on the blowing shaft, forming a double gear. Cams *o o* and *p p*, placed at three equidistant points, compressed the bellows alternately, *o* being the cams for the bellows on the side of the stream, and *p* those on the other side. The bellows are shown at *r r*.

The base, *S*, *T*, *V*, *X*, of the furnace was square, measuring about 25 ft. on each face, *S*, *T* being the face on the trompe or the front side of the furnace, facing the area where the open-sand moulds were made, *T*, *V* the face termed the counter-vent, or that opposite the bellows, *V*, *X* the side of the plain masonry, *X*, *S* the side of the tuyere, and *S*, *K* a heart-shaped pillar situated between the embrasure of the tuyere and that of the trompes; expiratory canals, *f*, *g*, *h*, *i*, *j*, *k*, are shown by which the moisture escaped from the masonry without causing its distortion or fracture. The walls on the other two faces of the furnace were carried by iron bars that traversed the embrasures (compare with Fig. 2). The foundation, *R*, of the furnace was of rammed sand; *E* shows the crucible; *F* the dam (dam stone). Between *V*, termed the "route," and the dam was the opening of the tap hole. *Y*, *L* shows a pig mould; *m* a communication between the mould and a casting of a chimneyback. Near by this communication was a ball of clay that served to close the runner when the chimneyback was filled.

The door, *D*, led into a moulding shop situated between two other shops where moulds were made in loam and in sand in boxes. Y^1 shows another door into the shop between the drying shop to the left which had its back to the counter-vent face, *V*, *T*, of the furnace, and the shed to the right where the

loam moulding was done. *Z* represents the other door between the shed to the right where the sand moulds were made in boxes, and the bellows room to the left; *P* the door of the shed where the moulds and cores in loam were made, mounted on benches or beds, *s*, *s*, *s*, *t*, as used by moulders in loam, *t* being a bench on which a baluster is seen being moulded. The items marked *l l* by the door *D*, and *l*, *o*, *l* in the drying room were pieces of wood supported horizontally at any convenient height, against which were placed moulds or parts of moulds to be dried. The large drier is shown at *p* and the small drier at *q*.

Near the door, *P*, and to the right of the loam moulding shop are seen the stores of mixed loam, one being shown covered, and one at *y* uncovered. A staircase, *x* descended to the canal, M^1, N^1, to which the discharging hatches were furnished for the water supply. *H* shows a bridge over this stream.

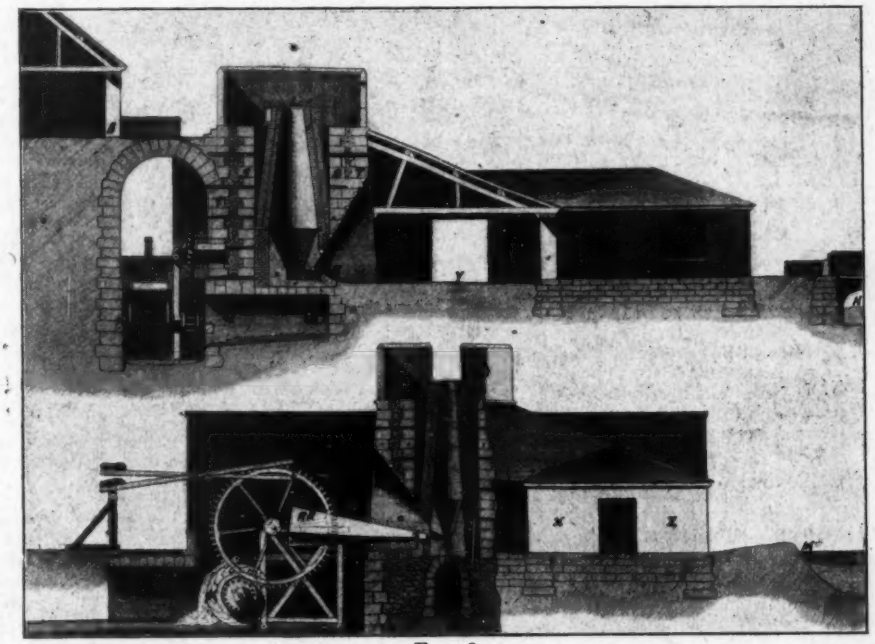


FIG. 2.

The other shed, seen in the lower right-hand part of the illustration, used for the moulding in sand in closed boxes, contained four moulding tables, *z*, *z*, *z*, *z*, each one being placed opposite one of the windows of the shed. The sand store is seen at *Q*.

In Fig. 2, the upper portion is a longitudinal section of the furnace taken through the trompe and an external elevation of the loam moulding shop. Below is shown a transverse section of the furnace taken through the tuyere and an elevation of the shop that contained the loam moulding and the double gear that drove to the bellows.

In the upper part, *A* is a part of the charcoal room; *B* the door of communication between this room and the top of the furnace, reached by passing over the bridge, under which runs the stream. The hatch, water-wheel, shaft, lantern wheel and cog wheel on the cam shaft which actuates the bellows are seen. *Q Q* is an arch or tunnel under the furnace, of about 6 ft. in height and 4 ft. in width, the object of which was to keep the lower part of the crucible dry. *F* is the dam, formed of a plate of iron, the bottom of which is filled with the same kind of sand, which is beaten to form the crucible. *L* is the furnace mouth; *T*, *T* the exterior walls; *S*, *S* the inner walls with rubble masonry. *Y* is the door of the shop located between the shed for moulding in loam and that for drying. *H* is the bridge over the discharging canal.

The lower part of Fig. 2 is a transverse section of the furnace through the tuyere. The stream *M*, *N* carried the water to the overshot wheel *K*, from which the water ran under a bridge that communicated with the discharge canal or tail race. *RR* represents one bellows, and just below is seen the other bellows, the first being shown lifted, the second lowered.

The base of the furnace is shown as cut through the middle of the tuyere, and through the small axis of the ellipse that formed the upper hearth. *X*, *Z* is an exterior elevation of the shed in which the loam moulding was done.

The relative proportions of the furnace are stated and discussed in very much detail in the original, from which we condense the following:— It was considered very advantageous to have the furnace very elevated, because then the slopes were less, the materials better digested, and one was able to measure the capacity of the various hearths. It permitted of multiplying the volume of air from the bellows, resulting in a larger heat. The author of the article spoke favourably of a furnace of 24 or 25 ft. in height. The furnace just described was 24 ft. in height from the base of the crucible to the opening at the top of the furnace, of which the large diameter was 2 ft. 9 in. through the trompe and only 2 ft. 6 in. through the tuyere. All classes of bricks, it was contended, were not equally proper for sustaining the continuous fire of the furnace. Those that were of most service were composed of white clay (*glaise*

blanche) mixed with a white sand, talc-like, and slightly ferruginous, which reddened slightly in the fire. Walls of this brick would resist for 20 years the fire of the furnace. This was also employed with great success in reverberatory furnaces. It was necessary that the paste of these bricks be well puddled or prepared by heating to produce the union or perfect binding of all parts, and that the bricks be dried to a dark shade and be well baked and matured for the following reason:—The carbon in the flame causes the ashes to stick to their surface and become vitrified, being in that state impenetrable to humidity during the interruption of the fire from one founding to another.

The bricks used for the walls were 12 in. in length, 6 in. in width at the tail, 5 in. at the exposed surface, and 2 in. in thickness when dried. It was deemed essential in the construction of the walls to employ a mortar composed as much as possible of the same clay as the bricks. The mortar was liquid enough to be blown in all the joints, so that no spaces should be left. For the construction of the large or superior hearth a templet was made of elliptical form, of which the larger axis measured 7 ft. and the smaller 5 ft. It was aligned with a templet at the top of the furnace by a plumb line.

The 25-Ton Air Furnace.*

By F. C. Rutz.

The malleable furnace has perhaps escaped being written about as much as any one subject pertaining to the malleable industry, and yet it is one of the most important. Improperly constructed or improperly handled furnaces are apt to wreck the best chemically calculated heat. Simple measurements of the openings between the top of either front or back bridge and the bottom of the bungs over them, are apt to make either for melting with just the proper oxidising flame or slow melting. The latter gives the flame too much play on a slow trickling of metal causing the familiar "high heat," or too low a silicon content.

A properly-handled furnace will cause the metal to collapse quickly into a molten state, giving the desirable "snappy" life and fluidity, with a consequent decrease in defective castings.

In my opinion, after having had experience with various sizes of furnaces, the 25-ton furnace has a sufficient number of points in its favour to warrant its adoption. These points include (1) decreased operating expense, (2) flexibility, and (3) space economy.

Let us first consider decreased operating expense. From cost figures available, the larger furnace can be operated at a total cost of 13s. 6½d. per ton, including firemen, coal, ash, slag and repair labour, all materials, tools and equipment. This figure is an average cost for the past four years, based on average heats of slightly over 18 tons. The charges are proportioned as follows:—

	Per ton. s. d.
Firemen, labour	1 0.5
All other labour	1 8
Coal	8 4
Brick	1 7
Fire sand and clay	2.5
Tools and equipment	8
Motor and fan repairs	0.5
Total	13 6.5

From figures available, obtained from a number of sources, covering costs on 12 to 15-ton furnaces, the cost of melting per ton averages approximately 16s. Owing, however, to different methods of distributing costs, a satisfactory comparison cannot be arrived at, itemised as above. The final result, however, seems to be greatly in favour of the larger furnace.

Regarding the melting ratio, a fair average covering a year's tonnage, actually poured, would be 2.75 to 1, after allowing approximately 13 per cent. for shrinkage on the total amount charged, owing to oxidation, slag, etc.

Taking up the question of flexibility, the advantage also appears to be greatly in favour of the larger furnace, owing to its adaptability for either large or small loads, depending upon the grade of work that one desires to make. Small heats of 12 to 15 tons can be handled as successfully as 20 to 25 tons, merely by keeping the bath of the metal at the proper depth.

In conclusion, let me present just a word regarding the detailed dimension figures of a successful 25-ton furnace. The grate surface is 5 ft. by 8 ft. The grate bars are 6 in. wide, with ⅝-in. openings. The opening from the top of the front bridge to the bottom of the centre of bung is 27 in. The back bridge opening is 12½ to 13 in. The lower blast pipe is 17 in. in diameter. The top blast is 6 in. in diameter. From it eight pipes having 2½-in. openings, pitched so as to strike at the base of the front bridge wall, extend through the wind bung. The height of the front bridge from the top of the grates is 40 to 42 in. The blast pressure is 5 oz. The above dimensions have proved the most successful among a number of experiments made to get the most economical results.

* Abstract of Paper read before the American Foundrymen's Association, September, 1916.

URANIUM IN HIGH-SPEED STEEL.—The effect of the alloy uranium on high-speed steel is shown by the results of tests of uranium high-speed steel in comparison with ordinary high-speed steel, given in the following table. The tests were made by the Standard Chemical Company, U.S.A., at a number of works in the Pittsburgh district:—

Material cut and tool.	Feed, inches.	Speed, f.p.m.	Cut, inches.	Remarks.
Loco axle:				
U	3/32	103	3/8	Ran 5 in.
A	3/32	103	3/8	Ran 2½ in.
Loco crankpin:				
U	1/16	74	5/8	Ran 12 in.
A	1/16	74	5/8	Ran 2 in.
U	1/16	64	5/8	Ran 8 in.
A	1/16	64	5/8	Ran 2 in.
U ..	1/16	75	1/4	Went over once distance of 14 in. On second lap went 3 in.
0.5 per cent carbon 12-in. shaft:				
B	1/16	75	1/4	Went distance of 4 in.
D	1/16	75	1/4	Went distance of 1 in.
8-in. shaft 7 ft. 5 in. long:				
U	1/16	51	5/8	Went over twice. Cut changed to ¼ in. on second turn.
C	1/16	35	5/8	Did not go 1 in.
6-in. shaft:				
U	1/32	75	5/8	Ran 18 in.
U	1/32	75	5/8	Ran 13 in. Speed increased to 90 f.p.m and ran 11 in. Tool still good.
B	1/32	75	5/8	Ran 11 in.
10-in. shaft:				
U	1/16	60 to 65	5/8	Went 8 in.
U	1/16	65	5/8	Went 4 in. Speed increased to 80 f.p.m. and went 3½ in.
12-in. shaft 22 ft. long:				
U	3/64	55	5/16	Went 16 in
U	3/64	55	5/16	Went 15 in.
B	3/64	55	5/16	Went 2½ in.

The tools marked A, B, C and D are regular high-speed steel tools. Those marked U are uranium high-speed steel tools.

Necessity of Apprenticeship.

The following is a lengthy abstract from a Bulletin issued by the Conference Board on Training of Apprentices which was established by various associations in the United States in 1915:—

One of the gravest problems facing the American employer to-day is that of obtaining competent workers. Owing to the rapid development of labour-saving machinery in industry, this need for competent workers did not become acute until the great expansion and development of industrial America, during the past two decades, made the problem of obtaining an adequate supply of competent workers a serious one. With something like 300,000 manufacturing establishments in the United States, each having its peculiar need of skilled or semi-skilled labour, and with relatively few employers giving serious attention to the proper training of their junior workers, rather depending mainly for their supply upon the chance of "picking them up" as needed, the growing scarcity of competent labour has at last forced American employers to realise the urgency of adequate apprenticeship training.

"What we have all been looking for," a leading industrial engineer has tersely said, "is the ready-made competent man; the man whom some one else has trained." Never before in the nation's history has this demand for "ready-made competent men" been greater than it is at present, with the supply altogether insufficient for the need. During the past five years a number of industrial surveys have been made by trade bodies and educational boards and each survey has demonstrated a great shortage in properly trained workers. A recent report declares that at least 1,000,000 young people are required each year simply to maintain the ranks of the nation's working population, and the Congressional Commission of 1914, which was appointed to consider the problem of industrial education, reports that hardly 1 per cent. of the 14,250,000 persons engaged in manufacturing and mechanical pursuits have had or at the present time have any chance to secure adequate training in their chosen industry.

These conditions prevail to-day in practically all industries. With few notable exceptions, no regular system of apprenticeship is employed, no particular rules are followed in hiring and retaining apprentice workers, and no organised system for their promotion in work or increase in pay is in vogue. Applicants are usually hired by foremen for their own departments, and the only training given these apprentice workers is that which journeymen give from time to time as convenience may permit or necessity may require.

During the past eight or ten years, however, increasing attention has been given each year to the consideration of the apprenticeship question. This awakening is directly due to the fact that, because of the sharp and increasing competition in the manufacture and production of almost all kinds of articles, manufacturers have been obliged to study closely the efficiency and productiveness of their plants, and in doing so have invariably discovered that the greater number of their skilled and semi-skilled workers are not as "skilled," nor even as "semi-skilled," as the conditions of to-day require. These employers have heretofore rested content in the belief that, when their factories and shops were equipped with the best and most modern labour-saving machinery, their labour requirements became of secondary consideration. They also felt that so long as their workers could perform with reasonable intelligence the relatively simple tasks in connection with the motions of the machines, and could be so specialised in the rapid performance of these machine motions that each machine would be kept producing to capacity, they had successfully met the conditions of shop efficiency, which in ordinary commercial language means large production at low cost.

Manufacturers soon found, however, through their studies for increased efficiency that simultaneously with increased production there occurred a large though preventable waste, which showed itself in three ways: in defective product; in worn machinery; and in increased cost of supervision. And the cause of this waste—a large annual total in most establishments—was easily traced to the lack of fundamental trade knowledge on the part of workers.

In some large establishments, particularly those in the metal trades where the management has been awakened to the necessity of stopping this waste and has undertaken to do so by careful training of apprentices in the practical technique of their trade, it has been found in consequence that the production of defective parts has greatly decreased, the cost of machine repairs has been much diminished, and, because of the increased individual intelligence on the part of workers, the cost of supervision has been materially reduced. Furthermore, it is the unanimous opinion of all employers who give their apprentices careful, systematic training, that the possibilities of production increase and of waste decrease through the development of individual intelligence are enormous, and, when combined with highly specialised machinery, will enable the American manufacturer to produce at a relatively low unit cost, even on the basis of the comparatively high rate of wages peculiar to that country.

The statements of two leading manufacturers in dissimilar lines, each of whom has given intelligent attention to the training of apprentices in finely equipped shop schools during the past several years, are interesting in relation to this question of increased efficiency and diminished wastage. The first employer, who normally employs about 1,100 workers, recently stated that, although the year 1915 was one of his poorest years from the standpoint of volume of business, the increased efficiency of his workers through the direct and indirect influence of apprenticeship training had enabled him to make a larger annual profit than during any previous year. The other employer stated that the standards of craftsmanship and trade intelligence were so high in his shop training school, and his third and fourth year carefully trained apprentices were so skilled, that his older less carefully trained employés were 'put to it" to do as skilful and as economical work as the apprentices.

To-day practically all employers, and all who are interested in the future of our country and in good citizenship, admit the importance of the apprenticeship question. We hear a great deal about conservation of our natural resources—but how about the conservation of our *human* resources? We also hear a great deal about preparedness—but how about preparedness of the individual worker that he or she may be an

economic producer, enriching our standard of civilisation, rather than a mere automatum, a lever pusher, simply following the worn ruts of wasteful producers?

It has been well said:—"It is highly important that we realise two things: first, that our most valuable resources are our people; and second, that we are wasting people more than we are wasting anything else. . . . Speaking generally, one is safe in saying that no nation ever did prosper as compared with other nations except by reason of its superior conservation of the human factor in production. In view of these large facts it is reasonably safe to say that the most destructive form of waste is the waste of labour power."

The great mass of American youth is absorbed in industry, yet by far the larger proportion goes into industry without sufficient academic training to develop thereon the best type of citizenship, or to give a firm foundation for subsequent specialised trade training. Of those who do possess the proper preliminary training, unfortunately but a small percentage is attracted to the learning of a trade. This is because the dignity of trade mastery has not been inculcated in the minds of parents and educators, although it is gratifying to record that, because of the agitation of this subject during the past few years, it is now receiving the attention of educators and parents as well as of enlightened employers.

In his monograph "Education for Efficiency," Dr. Charles W. Eliot says:—"By efficiency I mean effective power for work and service during a healthy and active life. This effective power every individual man or woman should desire and strive to become possessed of; and to the training and development of this power the education of each and every person should be directed. The efficient nation will be the nation made up by aggregation of individuals possessing this effective power; and national education will be effective in proportion as it secures in the masses the development of this power and its application in infinitely various forms to the national industries and the national service."

If employers will unite, through properly co-ordinated and effective apprenticeship systems, to work for this industrial efficiency by giving to their employés the opportunity "to acquire effective power for work and service during a healthy and active life," the dignity of a trade and the honesty of manual labour will receive new high values, and new standards of industrial ideals will be developed.

Responsibility of Employers.

Many employers, it should be said to their credit, are thoroughly alive to the necessity of apprenticeship training, and are doing all they can individually to awaken their fellow-employers to this industrial need. It is nevertheless a fact that most employers are giving little heed to the subject. The average employer, not from necessity but because of thoughtlessness or habit, still prefers to get workmen whom someone else has trained. When he employs one or more boys, he does so not for the purpose of making them skilled workers, but because there is a certain amount of "boy work" about the place which can be done cheaply by boys. There is not only a widespread indifference among employers to the proper training of young workers, but there is often a selfish objection to it. Many employers make the excuse that there is not sufficient time to teach boys the trade; consequently, they refuse to employ inexperienced young people, preferring to leave their training to others. These employers demand experienced workers and will take no others, except that they employ boys for boy jobs, and do not give even these a proper chance for advancement, so that they either have to migrate to other places where such chance is given, or remain for ever in the "lumper" class.

Limitation of apprentices by trade unions has helped to develop this condition of indifference on the part of employers. Many, however, do not employ the full allowable quota of apprentices which the trade union specifies, and often for professed convenience' sake and because they do not realise the investment value of apprenticeship training expense, employ none whatever. A student of this condition has well said, "Such neglect will prove in the long run to be the same sort of short-sightedness that leads the timberman to swell his immediate profits by denuding a forest, caring nothing for the predicament in which the future generation will be placed by such wholesale destruction."

Then there is the type of employer who does employ inexperienced young people and believes that he is doing his duty to his so-called apprentices by tolerating their presence in his shop, although he gives their training scant attention. These boys are forced to pick whatever trade knowledge and experience they can, supplementing it sometimes by the crude and kindly help of their fellow-workmen and occasionally by the advice of a foreman or superintendent. This type of "instruction" is more commonly in vogue than any other, a system of apprenticeship that is hardly worthy of the name; to it can be traced the large number of "botches" and inefficient men from which practically every industry is suffering.

From whatever point of view one considers such an "apprenticeship," it must be admitted that it does not meet the requirements of the industry, the needs of youth, nor the best interests of the employer. Such system or lack of system discloses the indifference of the employer, lack of forethought on the part of the boy and his parents, and a downright betrayal of apprenticeship education which should not be permitted in any enlightened community. This condition unfortunately gives some basis for the frequent condemnation of workshop training.

The youth who applies for admittance to a workshop, with the understanding given him on his employment that he is to "learn the trade," ought to be given the opportunity to develop his full mental and physical powers for the benefit of himself and his chosen industry. The responsibility rests squarely on the employer to give an adequate opportunity and to offer an effective training. The boy cannot be expected fully to realise the conditions surrounding his employment, its nature, its opportunities, and its difficulties. Because he has a job, he is content for the present. Yet when he is merely brought in contact with persons older than himself who take only slight interest in him or his advancement, he gets but little inspiration from the task to which he is assigned or from the meagre instruction that he may receive. It is this employer-indifference that has caused many thoughtful educators to insist that the teaching of a trade can only be done properly in some type of public vocational or trade school, whereas most enlightened employers who have studied this question and applied the results of their study in their own shops have come to the definite conclusion

that the technique and hand skill of a trade can only be taught effectively where the trade is practised.

But even though these employers believe that specific trade instruction should not be associated with fundamental public education which they consider essential for all boys and girls, whatever their future calling in life may be, they agree that the public schools can do much in preparing their graduates for serious trade study in industrial life by training them in school to think straight, to think in numbers, to think in drawing, to think in colour and form and proportion, and through the hand to give correct expression to the thought. Such school training will offer the right foundation on which to predicate specific trade instruction through apprenticeship systems.

When, however, trade instruction is given in public trade schools, it must be clearly understood that this type of education must be differentiated from the trade training which can be obtained in the shop, as the public trade school can teach only part of the required technique; the remainder must be acquired through practice on actual work under trade and commercial conditions. In the case of trade instruction through apprenticeship, on the other hand, the public school can effectively supplement shop study and shop work through correlated continuation instruction, even though the shop apprenticeship system provides, as it should, for trade training through practice in actual work and for applied instruction in related sciences, in order to develop both a mastery of the trade and an industrial understanding and intelligence.

The most effective way to impart these two divisions of training is to associate them as closely as the particular business will permit, so that trade training and theoretical classroom instruction may be practically simultaneous. It is manifestly unfair to the apprentice who undertakes to learn a trade to furnish him with less than full opportunity to perfect himself as an intelligent and efficient craftsman. It is unfair to the trade itself and to the efficient craftsman engaged in it to turn out half-equipped workmen who parade as trained craftsmen, but are not competent to prove their right to the title by the excellence and intelligence of their work.

For the best interests of industry, apprenticeship training must be so practical and comprehensive as to produce all-round development of each individual in his chosen trade, to the end that those who are to be accepted in a trade as craftsmen of recognised standing may be fully capable of performing the work as it should be performed.

Now if we are to have efficient craftsmen "fully capable of performing the work as it should be performed," this naturally requires that there be standards of craftsmanship—standards that shall be recognised in each trade by both employer and worker.

Unfortunately there have not been, heretofore, any general standards of craftsmanship, specialisation in a specific operation being often the only requirement for employment upon the part of the employer. Upon the part of the worker even this relatively simple requirement meant little as a standard, so long as he worked no more than the agreed-upon hours and received the prevailing rate of wages.

With the awakening of the employer to the necessity of apprenticeship, however, and the golden opportunity which it will provide for manning his shop and machinery with highly skilled workers, it will be relatively easy to establish and adopt standards of craftsmanship for each industry. To say that the adoption of such standards will revolutionise industry is to put it mildly, because no employer will undertake to train apprentices simply to perform the operations now being done by his present workers. On the contrary, the employer will train for much higher efficiency: he will combine practical trade training with a degree of technical instruction that will result in workers of a much greater degree of skill and a more highly developed craftsmanship.

Recognised standards of craftsmanship will do more toward asserting and maintaining supremacy in the world's business than almost any other one thing. They will result in giving to the manufacturer a product of a standard otherwise impossible; they will give him an increased output; they will give him intelligent workmen who will take pride in their work.

Standards of craftsmanship will do even more for the worker, for they will develop to the utmost such talents as he may possess, bring to the surface any latent skill of a special order that he may have, and permit him to develop himself fully both mentally and physically. They will spur ambition, increase his earning capacity, and make him a better citizen.

But are we to have an apprenticeship system? Shall there be a revival of apprenticeship in industry? Are we to have this higher type of workman? The employer is the key to the situation. Every employer of labour should give the suoject of apprenticeship training earnest thought, because, unless employers awaken quickly to the necessity of developing an adequate and continuing supply of intelligent workers who shall be masters of their craft, the day will speedily come when American-made products will largely be supplanted by those of foreign manufacture.

Necessity for Fundamental Uniform Action.

The problems confronting the employer who seeks to solve the apprenticeship question in his own factory or shop, also confront all other employers in a given industry. Furthermore, not every employer would be sufficiently informed upon the details necessary to conduct successfully a modern apprenticeship system; what would therefore be more natural than for employers in a given industry to apply co-operative effort to the problem of apprentice training exactly as co-operative effort has been successfully applied to other important questions?

Uniformity of action by employers in a given trade in the training of apprentices is not only entirely possible, but it must be practised if any material success is to be obtained, because the problem of training of apprentices has many complexities which concerted action alone will simplify.

For instance, one of the first questions which confront the employer who seeks to develop a higher state of efficiency and skill in his workers through the operation of an apprenticeship system is the question of, What shall be taught? Closely related to this question is, How shall instruction be given?

Now if each employer must work out the solution of these questions by himself, one can readily foresee a great deal of duplication of effort. Also if each employer shall be obliged to formulate his own policy and system, it does not take much imagination to see that a machinist-apprentice in

one shop will receive entirely dissimilar instruction from that given to machinist-apprentices in other shops, the degree or quality of instruction depending largely upon the employer's breadth of view and his personal capabilities as a trade educator.

While it is not to be denied that some shops require specialised talent for their particular kind of work as contrasted with the work generally performed in shops in the same industry, nevertheless there are many trade essentials which every apprentice in a given trade must absorb and master before he can specialise.

In order to indicate wherein uniformity of action by employers in a given trade is essential to successful apprentice instruction, it might be well to consider briefly some of the factors that enter into it, for example:—

Length of Apprenticeship.—Shall it be two, three, four, five, or more years? While an occasional apprentice may show unusual adaptability and develop very fast, each trade nevertheless should have a recognised apprenticeship period of such duration as to give adequate training to the average apprentice.

Agreement of Apprenticeship.—Shall the employment of apprentices be by verbal agreement, with no assurance that the apprentice will clearly understand and remember the terms under which he entered upon his training, as well as his promises for faithful performance of duty? Or shall the employment be based on a written agreement that shall specify the relationship between apprentice and employer and assure to each a continuance of that relationship during the period of apprenticeship?

Apprenticeship Wage.—Shall the apprentice be paid by the hour, the day, the week, or by the piece? Shall he receive specified increases at specified times? Shall apprentices of a given trade receive uniform pay throughout the trade, or shall each shop set its own wage schedule?

Character of Practical Trade Training.—What operations can be agreed upon as the major operations of a given trade? Which of these major operations shall an apprentice master in order to be considered a competent workman? How shall these operations be taught, and how shall training therein be linked up with the technology of the trade?

Character of Applied Technical Instruction.—Shall instruction of apprentices consist only of hand movements, or shall it include mental as well as manual instructions? What shall applied technical instruction consist of? What shall be required of an apprentice in the mastery of the mathematics, mechanics, and chemistry of his chosen craft and of the mechanical drawing related thereto?

Standards of Craftsmanship.—Shall there be standards of progress which each apprentice must attain in order to be assured of advancement, and what tests at the expiration of his apprenticeship term shall determine his competency in order that he may be certified as a skilled worker?

Certificate of Apprenticeship. — Shall a graduated apprentice receive a written certificate testifying to his apprenticeship, its duration, its character, and the time of its termination?

The above are only a few of many similar questions which can more satisfactorily be answered by joint deliberation of interested, thoughtful employers than by any one of them alone.

Annual Convention of American Foundrymen.

The annual joint convention of the American Foundrymen's Association and the American Institute of Metals was held in Cleveland (U.S.A.) on September 11 to 15.

The technical programme of the Foundrymen's Association was most comprehensive, contained forty papers and addresses and eleven committee reports, while twenty-one papers also were presented before the Institute of Metals. To provide ample opportunity for discussions, simultaneous sessions were held on certain days. The final business meeting was on Friday, September 15, and at the joint opening session, on Monday, September 11, the reports of the officers were submitted, and the negotiations leading to the management of the exhibition of foundry plant by the two allied associations and the incorporation of the American Foundrymen's Association outlined. Local and national official recognition was accorded the convention this year. An address of welcome was delivered by Hon. H. L. Davis, mayor of the City of Cleveland, and Hon. Newton D. Baker, secretary of war, delivered an address at the banquet which followed.

The programme of the American Foundrymen's Association contained three interesting symposiums, respectively on the gating of castings, the relation of the engineer to the foundry, and the manufacture of electric steel castings. A new safety code for iron, steel and brass foundries was presented for adoption, while the report of the Committee on Foundry Scrap represents the first effort on the part of any organisation to bring order out of the chaos which exists in the purchase of this material. The reclamation of waste foundry sand was another topic that was considered by several authors.

Exhibition of Foundry Plant.

Prior to 1906, individual manufacturers of foundry devices displayed their product in the rooms of the hotels where the headquarters of the American Foundrymen's Association were established, but in the spring of 1906 a half-dozen manufacturers of foundry equipment, in Cleveland and vicinity, formed an organisation for the conduct of an exhibition. This first attempt, while not nearly on so extensive a scale as the show this year, proved to be a marked success, and the attendance was fully three times as great as that at previous annual meetings, which did not include an exhibition of this kind. In that year the membership of the American Foundrymen's Association was only 300, but with this added stimulus it climbed beyond the 500 mark in 1907, and reached nearly 700 the following year. At that time the membership included brass foundry operators, who since have organised the American Institute of Metals, but notwithstanding this transfer of membership, the present enrolment of the American Foundrymen's Association is nearly 1,000, and that of the Institute of Metals nearly 400.

Following the Cleveland meeting in 1906, the exhibition was continued by the Foundry Supply Manufacturers' Association, which was organised to further this movement, and this year, for the first time the exhibition was held under the joint auspices of the American Foundrymen's Association and the American Institute of Metals. At the initial exhibition in 1906 forty-two companies made displays. This year about 150 individual exhibits were installed.

The Iron and Steel Institute.

The Autumn Meeting of the Iron and Steel Institute was held at the Institution of Civil Engineers, Great George Street, Westminster, on Thursday and Friday, September 21 and 22, the President, Sir William Beardmore, Bart., occupying the chair.

We reproduce in this issue abstracts of some of the Papers read at the meeting.

Formation of Scientific and Technical Committees.

THE PRESIDENT read the following statement:—With a view to encouraging the members of the Institute to take more interest, if possible, than hitherto in the affairs of the Institute, it is recommended by the Council that Committees be formed to report on new developments in the industry and to assist in obtaining practical Papers thereon. Such Committees might be five in number dealing respectively with:—(*a*) Mining, fuel, refractories. (*b*) Pig-iron, foundry practice. (*c*) Steel and alloys. (*d*) Mechanical treatment. (*e*) Physics, chemistry, microscopy. In addition to these Committees, a Research Committee might be formed for the purpose of suggesting and advising on subjects suitable for investigation and research.

The five Technical Committees should be constituted as follows:—They should consist of about eight members each. The Council to appoint one or more members of Council to each Committee, and the six other members to be chosen from among the members of the Institute. For this purpose nomination papers should be prepared and every member of the Institute be invited to nominate not more than six members for each Committee. A list of the nominees, placed in order according to the number of proposers of each, to be submitted to the Council, who will make the final appointment to the Committees, regard being also taken to some extent to the representation of districts.

The members of all Committees to be appointed for four years, and one-half of the Committee to retire every two years, the retiring members being eligible for immediate re-election. The Council to decide whether a new general nomination is to be resorted to on every occasion. In the first instance, retirement of one-half of the Committee will have to take place after two years, and it can be decided by ballot, or any other convenient means, which shall be the first members of the Committee to retire. Thereafter retirement to take place in regular rotation.

The Research Committee to consist of one or more members of Council appointed by the Council, and each of the five Technical Committees to nominate, say, one of their members to the Committee, so that it will consist of, say, seven or eight members.

Formation of a New Class of Members to be called Associates.

It is recommended that a new class of members be formed to be called the Associate Class, and that the following might be the conditions under which Associates can join the Institute. Candidates for election as Associates shall be persons not exceeding 24 years of age, and shall be:—(*a*) Students of metallurgy at a University or College. (*b*) Pupils or apprentices to metallurgists or engineers or in metallurgical or engineering works. (*c*) Persons employed in some practical or scientific capacity or in a metallurgical or engineering works. Associates shall pay an annual subscription of one guinea, and will be exempt from payment of an entrance fee. They shall have the right to attend all meetings of the Institute and to receive all notices and publications, but they shall not be entitled to vote at General Meetings.

Associates over 21 years of age, if qualified for membership, may, on application, be transferred by the Council to full membership, and will then pay an entrance fee of one guinea, and thereafter the usual annual subscription of two guineas. No Associate shall remain in the class of Associates after the 31st day of December next following the day on which he attains the age of 24.

Institute of Metals.

The annual autumn meeting of the Institute of Metals was held last month in the rooms of the Chemical Society, Burlington House, Piccadilly, London, Mr. George T. Beilby (President) in the chair. A number of Papers were read and discussed of which we append abstracts. The President was re-elected for the ensuing year.

The Development of the Spelter Industry.

In this Paper the author, MR. ERNEST A. SMITH, dealt with the history, methods of production, and industrial applications of zinc, and the present status of the zinc industry. In tracing the development of the spelter industry from its commencement in the 16th century, attention is drawn to the steady growth of the industry on the Continent during the last century. Germany, taking advantage of her natural resources in zinc ore and coal, early took the lead as the largest producer not only in Europe but in the world. For many years Germany remained the chief zinc producer, but in recent years very rapid strides have been made in zinc smelting in America, which now takes first place as the largest producer. The author submits tables showing the status of the world's zinc industry prior to the war, the figures giving the production and consumption of spelter in all the principal countries for ten years ending 1913, and also the average price in the London market. Reference is made to the Spelter Convention, which has hitherto largely controlled the output and price of zinc. In dealing with the ores of zinc, attention is drawn to zinc concentrates which now form so important a source of the metal, and the successful smelting of which has caused considerable difficulty in the distillation process. The various electric furnaces for zinc smelting and the hydro-metallurgical processes of zinc extraction are briefly described. The industrial uses of zinc are considered in detail, special attention being given to the zinc alloys. In this connection the author considers that the extension of the uses of zinc in the future will be dependent in no small degree on the discovery of new alloys suitable for industrial purposes. With regard to the future of the spelter industry, the author draws attention to the efforts that are now being made to increase the smelting capacity of the works in this country and in Australia, so that they may deal satisfactorily with the large quantities of zinc ore found within the British Empire.

The Annealing of Arsenical Brass containing 61 and 6·25 per Cent. of Copper.

In this Paper MESSRS. C. H. MATHEWSON and E. M. THALHEIMER (Yale University, U.S.A.) present a study of the structure and properties developed by varying the rate of cooling within the transformation range. During the summer of 1914 the authors were called upon to make

tests for the purpose of selecting a brass mixture based upon the use of Copper Range copper—a "Lake" brand containing about 0.3 per cent. of arsenic—and of specifying forms of heat treatment which would give satisfaction in the manufacture of heavy tube. The particular process for which this material was intended consists essentially in hot-rolling a thick cake to a circular disc about ½ in., annealing and then cupping the disc, after which tube is produced by a number of closing in and drawing operations, each preceded by annealing treatment. It is thus apparent that the material must be adapted to hot working and, in addition, must possess a high order of ductility when cold, so that it may flow freely between the punch and die. As a result of preliminary tests on several mixtures, the authors recommended material containing 62.5 per cent. of copper, which, as ordinarily cast from Copper Range copper, would contain not more than 0.16 per cent. of arsenic. Using a high grade of spelter, there would be no difficulty in hot-rolling brass containing a considerably higher percentage of copper than this. It is their impression that the hot-rolling properties of these alloys are largely dependent upon the lead content and the amount of the Beta constitutent present at the rolling heat. The main purpose of the Paper is to present the results of tests which show comparisons between the properties of brass containing (1) 62.5 per cent. of copper and very little arsenic (0.024 per cent.), (2) 62.5 per cent. of copper and considerable arsenic (0.120 per cent.), and (3) 61 per cent. of copper and considerable arsenic (0.139 per cent.) after different forms of heat treatment. In general, it may be said that brass of this character made from arsenical copper is likely to afford a better combination of strength and ductility than metal made from electrolytic copper when both are properly annealed. The authors are convinced that arsenical brass of this type will meet severe hot- and cold-working requirements. With regard to heat treatment, it is agreed that, in order to obtain the most favourable conditions for cold-working, a brass containing 61 per cent. of copper (and this probably applies to ordinary Muntz metal containing 60 per cent. of copper), annealing, if conducted at temperatures above moderate red heat, should be followed by at least a moderately slow rate of cooling, say 20 deg. C. per minute, and slow cooling should be continued to a temperature not far above 450 deg. C. If the metal is higher in copper, viz., if it contains some 62 to 63 per cent. of copper, emphasis should be laid on very slow cooling; for example, a 5 deg. rate is far more satisfactory than a 20 deg. rate, and in such case the metal should be allowed to cool normally to some 550 deg. C., whereupon it may be quenched in a stream of water if desired. In case a rate of cooling in excess of 20 deg. C. per minute prevails, it will be advantageous to allow such cooling to proceed unchecked to 450 deg. C., or even a lower temperature.

Cadmium in Spelter.

The author of this Paper, MR. W. R. INGALLS (U.S.A.), remarks that in view of the importance of brass to the cartridge-case maker the latter has to take every precaution that his alloy is pure. Cadmium is one of the impurites that has to be guarded against. It occurs in most samples of spelter to a greater or lesser extent. The author makes the interesting statement that the electrolytic process of zinc extraction affords an easy means for the separation of cadmium. He says that it should be borne distinctly in mind that the electrolytic process is going to be commercially applicable only under some specially favourable conditions, and is not going to drive zinc smelting out of the world's arts. However, the electrolytic zinc production that is likely to endure should go a long way toward meeting the demand for high-grade spelter, and especially for spelter low in cadmium. It appears that a good deal of the high-grade and intermediate spelter that America has sold to Great Britain at fancy prices during the last eighteen months has been redistilled common spelter. Mr. Ingalls suggests that Great Britain ought to have bought common spelter and redistilled it herself.

Effects of Mixtures on Strength of Chilled Car Wheels.

In a Paper read by G. S. Evans before the meeting of the American Foundrymen's Association last month were given results of a series of comprehensive tests of car-wheel mixtures made at the Lenoir Car Works, Lenoir City, Tenn. The tests, which extended over a period of two years, were undertaken to determine the relative strength of wheels made from mixtures containing varying percentages of coke and charcoal pig-irons, when made under uniform foundry conditions. During the tests, wheels were cast from some 60 different mixtures, some of which carried as much as 60 per cent. scrap steel; others contained 85 per cent. charcoal and coke pig, and still others as much as 98.5 per cent. scrap wheels. It was found that wheels could be made from all these mixtures that would meet the requirements of the latest Master Car Builders' Association specifications. Over 15,000 wheels were cast from the special mixtures and over 1,000 were tested to destruction. The following conclusions were arrived at as a result of these tests:—

No gain in strength is obtained by increasing the percentage of either charcoal or coke pig-iron beyond approximately 12 per cent. The substitution of charcoal pig-iron for coke pig does not result in any clearly defined beneficial effects on the strength of the wheels as shown by various tests. The effects, if any, of the different mixtures on the microstructure of either the chilled or grey portions of the finished wheels is not of such a nature as to be clearly defined. The foundry practice, including the melting, casting and annealing, appears to be largely responsible for the ultimate strength of the finished wheels, and the greatest possible source of betterment of the output as a whole results from the standardisation of this practice.

A CAST-STEEL WHEEL WITH MANGANESE TREAD AND FLANGE.—A one-life, cast-steel wheel with a manganese steel tread and flange and a ductile steel plate around the hub has recently been introduced in the electric railway field by the American Steel Foundries of Chicago. It is known as the Davis steel wheel, and its first cost approximates that of a rolled-steel wheel. Its durability, however, is similar to that of a cast-steel wheel, or even better, because of the tough wheel-tread and flange produced by manufacturing them of manganese steel. The method by which the two kinds of steel are incorporated in one casting was devised especially for the manufacture of the Davis steel wheel. It includes revolving the mould, in which the first metal entering is treated with ferro-manganese during its passage from the ladle into the mould, when the centrifugal action throws it to the wheel-tread and flange. As the pouring continues, the manganese steel rim is gradually blended into a ductile steel plate and hub by tapering off the ferro-manganese treatment. The advantages claimed for the wheel are that it retains the one-wear principle of the cast-iron wheel and at the same time secures greater strength, safety and lower maintenance cost. It also avoids the disadvantages of a rolled-steel wheel introduced by turning, which must be followed by adjustments in the bearings and brake rigging whenever the wheels are changed. The extraordinary strength and resistance to wear obtained by the combination of metals in the Davis steel wheels make it possible to produce them in weights lighter than could be obtained in any other metal.

Manufacture of Alloy Steels.

(*Continued from page* 469.)

High-Speed Tool Steels.

High-speed tool steels, also called rapid steels, have in the past fifteen years worked a remarkable revolution in the machine-shop business of the whole world, affording largely increased outputs and commensurate lower costs. As a consequence they are now being used very generally and in some shops almost exclusively for machining iron and steel as well as some other metals by cutting operations by machine tools.

The revolutionary feature wherein tools made of high-speed steel differ from and exceed in service the tools formerly used is their ability to maintain a sharp strong cutting edge while heated to a temperature far above that which would at once destroy the cutting ability of a simple steel tool. Because of this property a tool made of high-speed tool steel can be made to cut continuously at speeds three to five times as great as that practicable with other tools, and when, as the result of the friction of the chip on the tool, it may be red-hot at the point on top where the chip rubs hardest, and the chip itself may, by its friction on the tool and the internal work done on it by upsetting it, be heated to a blue heat of 296 deg. C. (565 deg. F.) or even hotter to perhaps 340 deg. C. (644 deg. F.).

This property of red-hardness or ability to retain hardness at a red heat may be imparted to steels of suitable composition, comprising chromium and tungsten, by a unique heat treatment to which they may be subjected.

High-speed tool steels are all made by the crucible or electric-furnace process. Except at one works, the crucibles or pots are made of graphite. The average life of the crucibles or pots varies in different works from six to nine melts. Some makers use clay-lined graphite pots in melting this steel to prevent or hinder the absorption of carbon from the pot. The clay lining is only one-eighth to three-sixteenths of an inch thick and is sometimes cut through on the second or third melt; in that event the molten steel may absorb too much carbon. Other makers use a graphite pot twice—first for melting other kinds of steel and then for rapid steel when the inner surface of the pot is somewhat slagged over, because of which the absorption of carbon is much less than when the pot is new.

The large producers use gas-fired melting furnaces for heating the pots, which are charged into the furnace at the top. Each melting hole contains six pots and each pot takes a charge of 90 or 100 pounds.

The charge is melted and then "killed" in the usual way by being held 30 to 40 minutes. Such procedure, together with the presence of the large amount of alloy, regularly gives sound piping steel. If run continuously a furnaceful of pots will be melted about every four hours.

In packing a pot with a charge for rapid steel the tungsten must be placed on top of the charge—as with simple tungsten steel—to guard as far as possible against the tendency of the tungsten to settle because of its high specific gravity. That tendency seems to be less with the rapid steels than with the simple tungsten steels. Whether the chromium of the former influences or hinders the settling of the tungsten is conjectural.

The smaller ingots, which are made from one pot of steel, vary from 3½ to 5 in. square. The steel is sometimes teemed directly into the mould by hand-pouring, but in some works clay funnels are placed on top of the mould to direct the stream down the centre of the mould to avoid cutting its wall, as might happen if the stream impinged on it. Funnel pouring is also advantageous when two pots are to be combined to make a larger ingot, as the steel can be poured into the funnel from opposite sides at the same time, a procedure that will mix the liquid steel and give a more uniform ingot than when one pot follows another, as in hand pouring when no funnel is used.

Some of the larger producers of rapid steels use for casting a large bottom-pouring ladle into which the steel is poured from the pots of one or more furnaces, and from which the ingots are top-cast; that is, the moulds are filled from the top. This method presents the advantages that (1) the product is more uniform; (2) individual pot charges, which might not be of the prescribed composition or might be otherwise unsatisfactory, are merged with the others without detriment to the whole; (3) large ingots are easily made; (4) one analysis serves for the whole number of pots; (5) one test serves for the whole ladleful of steel. It is a matter of experience that complaints from customers became much less frequent after the introduction of the ladle for casting this steel.

The strong tendency of rapid steel to pipe is checked considerably in most plants by the use on each ingot of a hot "dozzler," which is a clay ring preheated red hot, that is placed on the ingot top and filled with molten steel. This arrangement keeps the top of the ingot molten long enough so that the pipe is of diminshed size and nearly or quite all contained within the part of the ingot surrounded by the dozzler. The proportion of the ingot to be rejected on account of the pipe is therefore much decreased. The moulds are usually closed at the bottom end, and are either made with parallel walls or tapered so that the ingot is larger at the top than at the bottom. The moulds must be split when the walls are parallel, and are sometimes split when the ingots are tapered.

High-speed tool steel as cast has a coarse structure and dark colour as compared with the structure and colour of simple steels of the same carbon content. A corner is broken from the top of each ingot, to show the grain, and the ingots when hand-poured directly from the pots are classified by the eye as in the production of simple crucible steels. If the ingots are cast from the large ladle a test is taken for analysis which determines the composition of the whole ladleful of steel.

As a rule the ingots show a strong columnar structure or arrangement of crystals whose axes are normal to the cooling surface. Some makers refer to the structure as a "lemon structure," the crystals of the metal being thought to resemble the cells forming the pulp of a lemon. If the casting temperature is lower than usual, this lemon structure may be absent, and in that case the interior of the ingot will have a much finer grain than the ingots cast at the usual higher temperature. The subsequent heating and working of the

steel entirely destroys the crystalline structure of the ingot, and the worked steel, on a fresh fracture, shows a most beautiful porcelanic structure.

The ingots run from 3½ by 3½ in. to 16 by 16 in., but most of them are from 5 by 5 in. to 9 by 9 in. For hot working they are heated in a furnace chamber having a temperature of about 1,180 deg. C. (2,156 deg. F.). At this high heat the steel may be worked satisfactorily under the hammer or press and may be quickly worked down to the dimension desired.

Composition of High-speed Tool Steels.

The tendency of the makers is towards a somewhat uniform composition as regards the contents of the alloying elements, whose benefits have become fairly well known, and whose use as a consequence may be considered as established. Specifically, these alloying elements are tungsten and chromium. The addition of vanadium and cobalt in important proportions is considered by some makers to give distinct improvement to high-speed steel and some vanadium is almost always present. The following analyses are of steels recently made, most of which are considered to be good commercial steels:—

heat treatment all must be done correctly or the final result will not conform to expectations.

Carbon in High-speed Tool Steel

The proportion of carbon aimed at in high-speed tool steels is about 0.65 per cent., which in a simple steel would not be enough to give the maximum hardness even if the steel were heated above the critical point and quenched in water, and still less so when the steel is cooled as slowly as these steels are in their treatment. This shows that the carbon acts in a different way from what it does in simple steels, as is discussed later.

Tungsten in High-speed Tool Steel.

Tungsten is well established as a most important if not indispensable ingredient of commercial tool steels, being almost or quite universally used in quantity therein. The best proportion of tungsten, all things considered, seems to lie between 16 and 20 per cent., the tungsten content in 95 per cent. of all the American steels coming within these limits. Some published analyses of European high-speed tool steels show a higher content of tungsten than this, but American makers generally agree that any tungsten in excess of 20 per cent. adds

Analyses of High-speed Steels made in 1913 *or* 1914.

Sample	C.	Mn.	Si.	S.	P.	Cr.	W.	V.	Co.	Ni.	Mo.	Remarks:
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
A	0.65	0.15	0.20	0.02	0.02	4.75	17.50	0.90	—	—	—	
B—1	0.66	0.27	0.14	0.04	0.05	4.51	17.48	0.70	4.22	0.17	—	
B—2	0.74	0.31	0.13	0.04	0.02	4.20	15.63	0.67	2.70	—	—	
B—3	0.63	0.14	0.07	0.04	0.05	4.26	17.16	0.45	3.80	0.20	—	
B—4	0.69	0.34	0.14	0.03	0.04	5.28	16.35	0.64	5.28	—	—	
C—1	0.66	0.22	0.17	0.03	0.02	3.44	16.51	0.73	—	—	—	
C—2	0.64	0.21	0.16	0.03	0.03	3.30	16.06	0.66	4.02	—	—	
C—3	0.67	0.33	0.25	0.02	0.02	3.85	16.06	0.70	—	—	—	
D—1	0.75	0.28	0.36	0.03	—	4.10	19.00	0.75	—	—	—	Good.
D—2	0.68	0.38	0.40	0.03	—	4.65	17.85	0.53	—	—	—	Inferior.
D—3	0.69	0.36	0.38	0.04	—	4.67	17.90	0.50	—	—	—	Do.
D—4	0.57	0.20	0.26	0.02	0.03	4.82	15.38	0.50	—	—	—	Do.
E—1	0.61	0.23	0.35	0.04	—	4.10	17.20	1.00	—	—	—	Good.
E—2	0.68	0.45	0.40	0.04	—	4.00	14.26	1.09	—	—	—	Inferior.
E—3	0.70	0.50	0.39	0.05	—	4.08	14.50	1.07	—	—	—	Do.
E—4	0.60	0.23	0.12	0.03	0.02	3.90	17.27	0.90	—	—	—	Do.
F	0.64	2.29	0.12	0.02	0.01	4.39	16.09	0.59	—	0.28	—	
G	0.72	0.37	0.18	0.03	0.02	4.50	13.30	2.50	—	—	—	
H—1	0.77	0.16	0.21	0.02	0.02	4.05	18.64	1.35	—	—	—	
H—2	0.67	0.16	0.20	0.02	0.02	4.66	13.86	1.08	—	—	—	
I	0.64	0.23	0.29	0.02	0.02	4.57	19.10	0.54	—	—	—	
J—1	0.64	0.30	0.26	0.02	0.01	2.93	18.71	1.22	—	—	—	
J—2	0.71	0.14	0.26	0.03	0.03	2.97	18.21	0.97	—	—	—	
K—1	0.55	Tr.	0.23	0.02	0.04	4.46	16.05	0.80	4.72	—	0.72	
K—2	0.70	Tr.	0.18	0.01	0.02	4.25	15.50	0.88	4.72	0.18	0.67	
K—3	0.74	0.31	0.13	0.04	0.02	4.20	15.63	0.67	2.70	—	—	

Samples A to I represented American steels, the numerals indicating different samples from the same maker; sample J represented an English steel; sample K represented a German steel. Samples D—1 and E—1 gave excellent results in a competitive test, whereas samples D—2, D—3, E—2, and E—3, manufactured by the same makers, gave distinctly inferior results in the same shop. The occurrence of nickel in four of the samples may have been accidental, having been due to nickel in some of the scrap steel used in the charge. Most makers now put in vanadium, and steel like that represented by sample G, which had the highest vanadium content of all the samples represented in the table, was the winner in a recent competitive test. The average specific gravity of the steels represented in the table was about 8.8, the increase over the specific gravity of iron being due chiefly to the tungsten content.

There are so many factors besides the ultimate composition that affect the value of rapid tool steels that no conclusion can be drawn from the analysis alone. The melting, hot working, and

nothing to the usefulness of the steel, and they therefore make that proportion the upper limit of the amount added. One effect of the tungsten is that the best percentage of carbon in rapid steel is but about half that required in simple tool steels intended for the same kind of service.

Chromium in High-speed Tool Steel.

The effect of chromium in high-speed tool steel, as in other steels, is undoubtedly as a hardener, entering into the double carbide of tungsten and chromium which gives or causes the proper cutting edge. Although the proportion of this element present in these steels varies considerably, it is always large, perhaps never less than 2 per cent. or more than 6 per cent. in American steels, and in European steels the upper limits is at least 9 per cent.

Molybdenum in High-speed Tool Steel.

The use of molybdenum in high-speed tool steels is being generally discontinued. Some makers for years manufactured molybdenum tool steels, but,

as a rule, they have either wholly discontinued its use or use a much smaller proportion than formerly, employing it as an auxiliary rather than a major constituent. The effect of molybdenum is similar to that of tungsten, but is more intense in that 1 per cent. molybdenum is currently considered to give about the same or greater hardening effect than 2 per cent. of tungsten. It gives a fine cutting edge.

Various reasons are assigned for the discontinuance of the use of molybdenum in these steels. Taylor found that molybdenum in rapid steels caused irregular performance; that steels of nearly the same composition and having had seemingly the same treatment gave large variations in the cutting speeds they would stand. One user specifies no molybdenum because it causes the tools to crack in quenching. A maker objected to molybdenum because molybdenum steel was apt to be seamy and to contain physical imperfections. A maker of ferro-alloys understands that molybdenum steel deteriorated upon repeated heating for dressing and treatment, seemingly because the molybdenum disappeared from the outer parts of the steel where it was exposed to the heat and where any volatile constituent could escape. This phenomenon recalls a proposal of Moissan to use molybdenum as a means of freeing molten iron of oxygen, as he found that the oxide of molybdenum was much more volatile than the metal itself. It may be, therefore, that the molybdenum at the surface is oxidised or volatilised, but for this waste to extend to any considerable depth implies either that molybdenum moves through the heated steel to reach the oxygen of the air, or, as is more likely, that the oxygen of the air penetrates the steel, reaching the molybdenum and oxidising it, the volatile oxide escaping from the steel.

The cost of molybdenum when its use was most general was much more than that of tungsten. Because of the falling off of the demand in recent years, however, the price of molybdenum has fallen to about that of tungsten, or to a fraction of what it was a few years ago.

It has been observed that in the Eggertz colour determination a high molybdenum content (4 to 8 per cent.) causes "missing" or invisible carbon when the content of latter element is high (0.4 to 1.2 per cent.).

Vanadium in High-speed Tool Steel.

Vanadium is used for high-speed tool steel in varying amounts, most makers using at least 0.5 per cent., although some run the vanadium content up to 1½ or 1¾ per cent., or even more, considering that such an addition increases in an important degree the value of the steel for tools. The effect of vanadium is considered to resemble in some ways that of chromium in increasing the hardness or red-hardness of the cutting edge. One maker makes two kinds of high-speed tool steel, the essential difference between the two being that one contains about 1½ per cent. of vanadium and thereby commands a higher price, whereas the other has little of this element, both kinds being intended for substantially the same service.

High-speed steels containing vanadium are generally classed as "superior" steels, and many, though not all, makers and users consider them distinctly better than the "standard" steels containing no vanadium, both on account of their actual cutting qualities at high speeds and on account of the length of time a tool will cut before it needs regrinding. The true value of vanadium in rapid steels must probably be held as not yet fully determined. The analyses given in the table show that all the samples contained vanadium, but in greatly varying amounts.

Cobalt in High-speed Tool Steel.

Cobalt now threatens to change tool-steel manufacture because of the properties it imparts. The recent great decline in price following the increase of the supply from the silver ores of the Cobalt district in Ontario naturally led to its trial as a steel-alloying element, and some excellent high-speed steels containing, in addition to the usual ingredients, about 4 per cent. of cobalt, have been obtained. This result was hardly to have been expected in view of the experience with nickel, which cobalt much resembles, as nickel has been condemned by nearly every manufacturer as not being a desirable ingredient of high-speed tool steels, because of the effect it has of making the edge soft or "leady." The cobalt steel, however, has shown, in some products at least, increased ability to hold its edge in work.

One user of cobalt steel found it better suited for turning manganese steel than any other steel he tried, his success being so marked as to make it practically a commercial operation. Manganese steel, as noted earlier, is so hard as to be considered practically unmachinable, the usual practice having been to finish it by grinding when necessary. Another user found that an imported cobalt high-speed steel proved excellent for cutting a hard nickel-chromium steel in a lathe, whereas the same steel in a cold saw was not satisfactory. The direct reason seemed to be that this steel to do its best work must be run nearly if not quite red hot; at least that was the condition in which it was used in the lathe, while in the cold saw its temperature was not raised to an important degree, and when cold its properties were different from when it was hot. This behaviour is more or less common to high-speed steel as is mentioned later. The valuable effect of cobalt is claimed to be that it increases the red-hardness of high-speed tool steel, enabling the steel to cut at a higher speed.

Copper-Sulphur and Phosphorus.

Copper has been considered to be highly injurious in high-speed tool steel, even as little as 0.05 per cent. being inadmissible; and it is thought to be particularly harmful if much sulphur is present in the steel; also the higher the carbon content the more harmful is the copper.

Sulphur and phosphorus, which are so deleterious in simple tool steels, are considered to be somewhat less so in high-speed steels, in which the effect is either modified or else masked by the large quantities of other ingredients. Some commercial brands of high-speed steels have as much as 0.05 per cent. of each of these impurities, to which no inferior quality is attributable.

Stellite.

Stellite, though a competitor of high-speed steels, is not within the scope of our subject, but a recent analysis is given of a sample for such interest as it may have in relation to cutting steels:—

	Per cent.
Co	50.50
Cr	10.77
Mo	22.50
C	0.87
Si	0.77
Mn	2.04
S	0.084
P	0.040
Fe	3.11

(To be continued.)

The Influence of Heat Treatment on the Thermo-Electric Properties and Specific Resistance of Carbon Steels.*

By Edward D. Campbell (University of Michigan).

In this Paper the author seeks to bring out, by experimental evidence, the correlation between thermo-electric properties and specific resistances of carbon steels which have been subjected to varying heat treatments, producing thereby progressive changes in the chemical constitution. It is pointed out that the thermo-electromotive potential of carbides in solid solution is of opposite sign to that of pure iron when these are both opposed to copper. This renders it difficult to interpret the results obtained from heat-treated steels when the thermo-electromotive potential of the steel as a whole over a given temperature gradient is opposed to that of copper, and the results of these measurements again compared with that obtained by opposing the thermo-electromotive potential of pure lead against copper with the same temperature gradient. If thermo-electromotive potential, like specific resistance, is an inherent property of steel, and is dependent upon the chemical constitution, it is evident that if strictly accurate results are to be obtained there must be no change in chemical constitution of the steel between the two points over which the temperature gradient exists.

After describing in detail the experiments conducted, the author presents tables showing (1) the results of the specific resistance measurements, all made at 25 deg. C.; (2) the differences in specific resistance after a given heat treatment, and that of the same bars reheated to 696 deg. C., at which temperature all the steels have their minimum specific resistance; (3) the results of the thermo-electromotive force developed between 0 deg. C. and 100 deg. C.; (4) the differences in thermo-electromotive force after a given heat treatment, and that of the same bars reheated to 696 deg. C., at which temperature all the steels have their minimum thermo-electromotive force. Three points which are strikingly brought out by an examination of the data and curves submitted are as follows:—

First, the parallelism between the thermo-electromotive force and the specific resistance of the different steels, as influenced by chemical composition and heat treatment, would prove almost conclusively that the total thermo-electromotive potential of steel, like the total specific resistance, must be considered as being made up of two components: that due to the solvent iron and that due to the solutes; the proportion of the total due to these latter depending upon the extent to which they are in solution.

Secondly, the transformation of the allotropic into the alpha form of iron by reheating is nearly completed after reheating to 300 deg.; but complete equilibrium, indicated by minimum specific resistance and thermo-electromotive force, is not attained except after long heating to about 700 deg.

The third point brought out by an examination of the data is that neither the specific resistance nor the thermo-electromotive force due to carbon in solution as carbides is directly proportional to the atomic concentration of the carbon. The data show that equiatomic concentrations of carbon as hypo-eutectoid carbides, produce only about one half the effect on the specific resistance and thermo-electromotive force as is produced by equal atomic concentrations of carbon existing in the form of the carbides of eutectoid or hypereutectoid steels.

* Abstracts of Papers presented before the Iron and Steel Institute.

Notes on Pearlite.*

By Henry M. Howe and the late Arthur G. Levy.

This Paper is a report of the progress of a study of how the properties and microstructure of eutectoid carbon steel, and the position, length, and rise of Ar1 in it, are affected by the conditions of heating and cooling. The steel treated contained: Carbon, 0.92 per cent.; silicon, 0.14 per cent.; manganese, 0.123 per cent.; phosphorus, 0.009 per cent.; sulphur, 0.011 per cent. The treatment was to heat to a predetermined temperature, which the authors call T max, usually 800 deg. or 900 deg., and to cool immediately at a predetermined rate, which varied from case to case from that of a greatly retarded furnace-cooling to that of a quenching in cold water. In most cases the cooling was continued to the room temperature without interruption or change, except of course its natural slackening as it goes on, but in several cases it was interrupted on reaching 650 deg., and a new rate, sometimes faster, sometimes slower, was set up.

The authors summarise their conclusions as follows:—

Hastening the cooling lowers Ar1 max from its equilibrium position of about 725 deg. C. at least to 625 deg. if not to 530 deg.

Raising T max from 800 deg. to 900 deg. lowers Ar1 slightly, about 5 deg.

Hastening the cooling at first increases the rise of temperature in Ar1, but later lessens it.

These variations in Ar1 are referred to corresponding variations in the degree of undercooling.

We propose two additional stages, sorbitic pearlite and sub-lamella pearlite, in the microstructural series between sorbite and lamellar pearlite. We would restrict "sorbite" to structures irresoluble under a magnification of 500 diameters, and to those in which the transformation is complete, so that no allotropic iron or hardening carbon is present.

The rate of cooling from 650 deg. down does not affect the microstructure or the tensile properties unless the cooling as far as 650 deg. has been at least relatively rapid.

The formation of lamellar pearlite is caused by an intermediate rate of cooling, slow enough to permit the lamellæ to form, yet not so slow as to allow them in turn to granulate.

The 900 deg. lamellar pearlite is coarser and more stable than 800 deg.

The rates of cooling which give and preserve lamellar pearlite are much faster when T max is 800 deg. than when it is 900 deg.

The microstructure is determined by the last heating and cooling past Ar1.

Every increment of the rate of cooling increases the strength and lessens the ductility.

Unless the rate of cooling is rather rapid, the tensile strength of the 800 deg. specimens is far less than that of the 900 deg. This is referred to divorce.

The 800 deg. specimens are far more ductile than the 900 deg. ones, and their proportional limit is not deficient as their tensile strength is, effects which we refer provisionally to the finer 800 deg. structure.

A longer heating to a given temperature is probably equivalent to a shorter heating to a higher temperature.

Use of By-Product Coke in Foundries.*

By Geo. A. T. Long.

The requisites of a good by-product foundry coke are (1) high carbon, (2) low sulphur, (3) good cellular structure, and (4) that the product shall be uniform. The carbon and sulphur are primarily the result of the quality of coal which is used in the ovens for coking purposes. The structure, however, depends on proper preparation of the coal before coking, as well as upon the arrangement of the ovens in which the coal is coked and upon the temperature of the coking chamber. It, therefore, does not follow that all by-product cokes are suitable for foundry use.

In using coke in the cupola, as little wood as possible should be used—just sufficient to ignite the coke. The height of the bed above the tuyere depends on the metal being melted. For ordinary soft grey-iron castings the bed should be brought up to 24 in. above tuyeres, settled and thoroughly burned through before charging any iron. With low-carbon irons such as steel mixtures, a higher bed is required, no less than 30 in. above the tuyeres after settling, as low carbon may require more fuel. The next question is, how much iron shall be used to a charge? I contend the charge that is put on the bed should be used all through the heat, whether the heat be five charges or 50, as the closer we can work to the melting zone the better will be the results obtained. I also believe in making small charges, as this practice gives a more uniform mixture, keeps the iron hotter and saves fuel. In the ordinary cupola 24 to 36 in. inside, I use 1,000-lb. charges; in cupolas from 36 to 54 in. I prefer 2,000 lbs. In cupolas larger than this, 3,000-lb. charges would be the limit, using 1 lb. of fuel to 10 lbs. of iron between charges, unless using steel mixtures. The larger the percentage of steel, the more fuel is necessary. For instance, with a 25-per cent. steel mixture I would use 150 lbs. of coke to 1,000 lbs. of metal, for I think the secret of all steel mixtures is in bringing the carbons up in order to get fluid metal.

The next question is, how much air should be used to get proper results? I do not think there is any one thing that varies so much in foundry practice as the air blown into the cupola. Seldom will two foundrymen be found of the same opinion or using the same air pressure. The pressure will range all the way from 6 to 30 ozs. I believe the lower the pressure the better the results obtained; the oxidation is less, the sulphur is lower, and the metal is softer and truer to mixture. High blast pressure tends to combine the carbon and reduces silicon and manganese, causing hard iron. If the coke does not have a good structure it will not stand up, and much the same trouble will result. A number of troubles attributed to coke, such as slag, hard iron, shrinkage, etc., can be all put down to high pressure.

In passing may be mentioned a complaint about sulphur investigated a few months ago. In this case the sulphur jumped up 0.15 or 0.20 per cent. in the castings, and immediately the coke was assumed to be the cause, for no change was said to have been made in the irons used. This was true, but upon looking into the matter I found that the use of ferro-manganese had been discontinued, owing to its high price, and this reduced the manganese as charged, about 0.40 per cent.

As to slag, when it starts right at the beginning of the heat it usually comes from too low a bed, which allows the air to reach the iron. With this condition slag will show at once. Very often I find the daubing used to line the cupola reducing to slag before the blast is put on; this is due to the nature of the clay used.

Some foundrymen think it is necessary to select large coke for the bed. This is a mistake, for all large-size coke permits the passage of air too freely. I find the best results are obtained by straight forking with no attempt to select large pieces for the bed. Large coke leaves too much air space, while a mixture of sizes packs enough to confine the air and keeps the blast from too direct contact with the iron. Trouble with cold iron at the start of a heat is often due to a bed of large-size coke, for with such a bed two or three charges must be melted before the coke settles properly.

I find that a great many foundries are using extra coke every few charges. I think this is an entirely wrong practice. They do this to renew a bed which has been lowered by melting too large charges of iron. As an example, a foundry I visited a short time ago has a cupola 42 in. inside measurement, with 13 in. from the sand bottom to the tuyeres. They were using 4,000 lbs. of iron to each charge with 450 lbs. of coke between charges. Every seventh charge they used 200 lbs. of extra coke. Still their iron was not right and they were troubled with slag. The cause of their trouble was too large a charge of iron and too much coke in a body. The charge of 450 lbs. of coke would fill up the cupola considerably above the melting zone, and would have to be burned down to the zone before it would do any work. The large charge of iron would then force the melting zone so low that the air would reach the metal. In charging this cupola, I simply cut out the extra coke and charged 2,000 lbs. of iron to 200 lbs. of coke, reduced the air from 16 ozs. to 10 ozs., and they have had no further trouble since this change was made.

In continuous melting, where a cupola is run from 10 to 18 hours a day, the charging is practically the same. It is not a question of how long one can run a cupola; it is a matter of how long the lining will last. I find the greatest trouble with continuous melting arises from the slag-notch closing up. I have not found anything equal to limestone for fluxing. The trouble with many cupolas built for continuous melting is that the slag-notch is too close to the tuyere. I think the slag-notch should be at least 10 in. below the bottom of the tuyeres; a slag-notch so placed practically will take care of itself and will not require continual poking.

In using by-product coke manufactured by people who are making a speciality of foundry coke a uniform product is assured, both in fixed carbon and sulphur. A uniform fuel is the greatest asset a foundryman can have.

* Read before the American Foundrymen's Association, September, 1916.

CASE-HARDENING COMPOUND.—The following case-hardening compound was the subject of an American patent by P. W. Brennan a few years ago:—Potassium cyanide, 2 oz.; sodium bi-carbonate, 1 oz.; potassium bi-carbonate, 1 oz.; bone-dust, ½ oz. The ingredients were powdered and thoroughly mixed. The iron or steel to be case-hardened was heated and covered with the mixture, after which it was again heated to a bright red and plunged into water.

D

Non-Ferrous Notes.

Imitation Gold Alloy.—A mixture which gives a very pleasing colour and can be used as an imitation of gold, is made of the following:—Copper, 81 per cent.; nickel, 9 per cent.; zinc, 10 per cent.

Flux for Sterling Silver.—In the manufacture of sterling silver in America the metal, prior to pouring, is deoxidised by adding metallic cadmium equal to 5 per cent. of the weight of the alloy. The cadmium is pushed down under the surface with tongs to prevent it rising to the surface and burning.

Gunmetal Finish on Brass Castings.—A method of obtaining a gunmetal finish on small brass castings is to first copper-plate them and then dip into a solution made by dissolving 2 oz. of liver-of-sulphur in 1 gallon of water. This should be used cold and after rinsing, the castings should be scratch-brushed with a soft, brass scratch-brush and then lacquered. A black-nickel deposit is also used for the gunmetal finish.

Alloy for Sparking-plug Points.—The following is the analysis of a sample of nickel wire made in Germany and used as the wire terminals of sparking plugs:—Nickel, 98.35 per cent.; iron, 0.83 per cent.; manganese, 0.69 per cent.; copper, 0.13 per cent. Pure nickel was first used for this purpose, but within the last few years an alloy of nickel and chromium, which melts at a much higher temperature than pure nickel, has been employed.

Copper in Lead-Antimony Mixtures.—When lead-antimony mixtures are required to be hardened copper is sometimes added, but it is not strictly satisfactory. From 0.50 to 1.00 per cent. copper slightly though not materially hardens the lead and antimony; while a larger quantity thickens the metal by increasing its melting point. Copper is not used to any extent, therefore, for this purpose, and can be employed only in small amounts.

Potassium Cyanide as a Flux.—Potassium cyanide is a white fusible salt, soluble in water, and intensely poisonous. It is one of the most efficacious and energetic fluxes known, as it has a strong reducing action. It has a good effect when used on melted sterling silver, and promotes soundness and malleability. It is objectionable, however, for the reason that it becomes quite fluid and is skimmed from the crucible with difficulty. It also attacks the crucible strongly.

Aluminium Solder.—The following rather complex mixture is one of the numerous aluminium solders that have been proferred from time to time. This was patented by C. R. Erkens in America:—Tin, 60 per cent.; zinc, 15 per cent.; lead, 10 per cent.; antimony, 5 per cent.; bismuth, 5 per cent.; chromium, 5 per cent. The metals were melted and then treated with "35 grams of salicylic acid and 10 grams of calcium to each 5 lbs. of the alloy; and for a like amount of material 2 grams of sulphur." The inventor stated that the sulphur acted as a "binding agent." The solder was stated to be used with the ordinary solder fluxes for soft solder and in the same manner.

Non-Corrodible Metal.—A so-called non-corrodible metal was the subject of a patent granted in this country to J. Coup and E. Allbaugh. The mixture consists of 69.13 per cent. copper, 14.81 per cent. nickel, 8.64 per cent. zinc, 0.58 per cent. lead, 0.06 per cent. iron, 3.08 per cent. phosphor-tin and 3.70 per cent. aluminum. When the alloy is to be used for making such articles as knives which are stamped or cut out, the phosphor-tin preferably contains 6 per cent. of phosphorus, but when the alloy is to be rolled, the proportion of tin is greatly reduced and may in some cases be omitted, the proportion of phosphorus in that case being from 0.053 to 0.76 per cent.

Large Gates in Casting Strong Bronzes.—The difficulties often experienced in casting manganese-bronze and other bronze containing aluminium can often be overcome by properly gating the mould so as to accommodate the shrinkage. The chief essential is to give the casting as large a gate as possible, so that the casting, being smaller than the gate, will cool first and draw what metal it needs from it. The cavity produced by shrinkage will then be found in the gate and not in the casting. The objection to large gates put forth by founders is the trouble involved in cutting off, and the excessive scrap in the form of gates to be melted. Bad castings, however, can readily be more expensive.

Making Porous Metals.—In the production of porous metals (other than those which, to the distress of the founder, sometimes appear as castings which were intended to be sound), use is made of the fact that the eutectic is liquid after the skeleton structure of first crystallisation has formed. An example is an alloy of 50 per cent. of antimony and 50 per cent. of lead allowed to cool to below 450 deg. C. At this temperature the antimony begins to crystallise out. If the mass is then subjected to centrifugal action, the liquid eutectic, which does not finally solidify until a temperature of 225 deg. is reached, and which then contains 87 per cent. of lead, is removed, and the porous antimony left. A tin and lead alloy can be made and treated in the same manner.

Aluminium-Zinc-Cadmium Alloys. — A malleable aluminium alloy, introduced by T. A. Bayliss and B. G. Clark, contained from 80 to 99 per cent. of aluminium, up to 20 per cent. of zinc and 0.001 to 10 per cent. of cadmium. Two alloys given as examples were:—(1) Aluminium 91, zinc 8, cadmium 1 per cent.; (2) aluminium 88, zinc 10, cadmium 2 per cent. The method of manufacturing the alloy consisted in adding zinc and cadmium to the molten aluminium, the mass being maintained in molten condition till the zinc and cadmium were evenly disseminated. The alloy was claimed to be extremely tough and strong and highly malleable when cast in chill moulds for rolling. Sand castings were said to have a fine smooth surface and be readily machineable.

Mixture for Name Plates.—A mixture suitable for making name plates, for which purpose lead alone is too soft, is composed of 87 per cent. lead and 13 per cent. antimony. This metal can be cast in sand, but takes every impression of the sand grains and hence has a rather rough surface. It is better, and cheaper if many castings are to be made, to use a bronze mould. This can be chased out so that the surface is smooth, and then the plates are smooth and of excellent appearance. It is preferable to melt the lead in an iron kettle and the antimony in a crucible in a pit furnace. When both are melted they should be mixed before removing the kettle from fire, just at melting temperature and no higher. As the antimony takes longer to melt, it should be started first.

Platinum and Aluminium Alloys.—Experiments were conducted by Chouriguine on the alloying of platinum and aluminium, by adding platinum wire to molten aluminium in an electric furnace. The oxidation of the aluminium was prevented by covering with lithium chloride. This was best accomplished by soaking the piece of aluminium in a solution of lithium chloride and allowing them to dry before melting, this preventing the oxidation of the aluminium during melting and also protecting it after melting. When containing less than 10 per cent. of platinum, the aluminium and platinum alloys were white, soft and very malleable. With increase of platinum from 10 per cent. to 70 per cent., the alloy was hard and brittle and still white. When containing above 70 per cent. platinum the alloys were yellow and brittle, the yellow colour disappearing at 90 per cent. platinum and the alloy becoming white again, yet still brittle. No commercial use for any of these alloys was suggested, owing to their brittle nature.

Iridium and Its Uses.—In connection with the use of iridium in metallurgical work (mentioned in our last issue in these notes) it should be stated that metallic iridium is made from the powder, obtained in the wet way from platinum ores, by heating to a high heat in a sand crucible and then adding stick phosphorus. The iridium, which cannot be melted alone, is thus fused in the form of an iridium phosphide. To remove the phosphorus, the phosphide is heated with lime and the iridium is left in the form of a hard, white mass. It is in that state so hard that it cannot be filed or cut, and is broken up into small pieces for soldering to the points of gold pens. These small pieces are ground to the right size with emery or car-

borundum. It is stated that the iridium so prepared is practically as hard as the ruby. No steel tools can make any impression upon it. At one time much less expensive than platinum, iridium now is worth more on account of the demand for hard platinum, in which the iridium is the hardening agent.

Japanese-bronze Finish on Brass.—A method of obtaining what is known as the Japanese-bronze finish on brass was described as follows in "The Brass World":—Give the article a light copper deposit in a cyanide-copper solution and then a deposit of about 30 minutes in an acid-copper solution. Now rinse and immerse in a liver-of-sulphur solution (used cold) made up of water 1 gal., liver-of-sulphur ½ oz. Immerse the work in the solution, and when the first discolouration takes place, remove, rinse and immerse in a weak acid pickle composed of 1 part of muriatic acid and 10 parts of water. This will "set" the colour. Now scratch-brush dry and the mahogany red will be obtained. If the colour is not sufficiently deep, then the articles can be returned to the liver-of-sulphur bath and the colour carried a little further. The object is to stop the colour when the right shade has been obtained, and for a "Japanese bronze" this point is produced when a slight discolouration has been obtained. The principal error is to carry it too far or to use too strong a liver-of-sulphur solution.

Small Leaks of the Brass Foundry.—In a paper by Chas. T. Bragg before the American Institute of Metals last month the author remarks that it is easier to make a large saving than a small one. The investigator always finds that everyone connected with a given institution easily understands his object and cheerfully aids in its accomplishment if it is large enough. However, no one is at heart willing to be wasteful, and any proposal to eliminate waste, which he can clearly understand, enlists sympathy. The writer holds that it would, however, be advantageous to standardise the means of selecting supplies and making small savings for three reasons:—(1) The moral effect of constant vigilance will soon develop in the casual employé a habit of thrift and watchfulness; (2) this method does not shut out the new things offered for consideration from time to time, but it does remove from the mind the uncertainty usually attending the adoption of a process or material which is "different"; (3) it installs that feeling of self-satisfaction that always comes to one who has his finger tips on the key to the situation, and permits one to listen to others with understanding.

Melting Points of Salts.—Metallic salts are largely used for hardening steel, as fluxes, and in other work in which melting or heating is carried out. The following melting points have been taken from Carnelly's "Table of Melting Points." As is fairly well known, a mixture of two salts frequently melts at a lower temperature than either.

	Deg. C.		Deg. C
Barium fluoride	1000	Magnesium chloride ..	708
Calcium fluoride (fluor-spar)	1000	Sodium chloride (common salt)	770
Potassium fluoride ..	790	Lead chloride	500
Lithium fluoride	801	Strontium chloride ..	825
Magnesium fluoride ..	908	Zinc chloride	262
Sodium fluoride	902		
Strontium fluoride ..	734	Boron trioxide (boric acid)	570
Silver chloride	451	Aluminum oxide	*
Aluminium chloride ..	180	Magnesium oxide	*
Barium chloride	960	Sodium nitrate	300
Calcium chloride	720	Potassium nitrate ..	340
Cuprous chloride	434	Potassium carbonate ..	830
Cupric chloride	498	Sodium carbonate ..	814
Ferric chloride (iron perchloride)	300	Lithium carbonate ..	695
Potassium chloride ..	730	Sodium silicate (water glass)	45
Lithium chloride	600		

* Infusible except at the highest known temperatures.

Mixtures for Saddlery Hardware.—A considerable variety of mixtures have been used for this work, in which it is desired to combine great strength and whiteness. For horse-bits German silver is generally too soft, and is difficult to cast soundly. A mixture which is exceptionally stiff and strong and has a good colour is:—Copper, 65.00 per cent.; nickel, 32.25 per cent.; aluminium, 2.75 per cent. It is advisable to nickel-plate it, as that prevents the slight tarnishing to which all copper and nickel alloys are subjected in the course of time. Castings of this mixture will bend considerably without breaking; or the mixture can be made much stiffer by increasing the aluminium slightly. To make the mixture (using the best metals) copper and grain nickel are melted together under a good layer of charcoal, and about 2 lbs. of borax is added to 100 lbs. of metal as soon as the copper begins to melt. When the nickel is melted, the whole is stirred and the aluminium is introduced. The metal then becomes white hot from the action of the aluminium, and should be stirred with a plumbago stirrer (not with an iron rod) and poured into ingots, which should be melted for the castings. A good heat is necessary for melting the metal, although not much more than for German-silver. It runs freely, and does not chill as quickly as might be expected from the presence of so much nickel. The addition of zinc cheapens the mixture and also whitens it a trifle, but causes the castings to crack in the mould. In stiffness this copper-metal-aluminium alloy is said to approach tempered steel.

Salt in Brass Melting.—When common salt (sodium chloride) is added to molten brass, as is common practice with brass-rolling mills, it has a marked cleansing effect by removing the oxides formed by the copper during melting. The salt on being heated dissociates into metallic sodium and chlorine gas, the latter's action on the metal, if any, being problematical. The sodium, however, has a strong affinity for oxygen, and also other non-metallic elements, and its effect is to deoxidise the copper. Zinc in brass also serves to reduce any oxide of copper present, but the resulting zinc oxide does not all come to the top, some of it being suspended in the metal. The particles of this zinc oxide are very minute and in many classes of castings are not deleterious, but usually some is present, though it is not as harmful as the original amount of copper oxide. The use of salt not only removes this oxide but largely prevents the wastage of zinc which would otherwise be lost as zinc oxide in the surface skimmings. The best method of using salt is to throw a handful on the copper as soon as it begins to melt and is well covered with charcoal, then stir it in; and when all has been melted, a little more can be added and stirred in. If an excessive quantity is used, a liquid mass will be found on the top of the brass when ready to pour. This is difficult to skim off and is apt to enter the mould with the metal. When the right amount is used, it should give a very pasty slag easily removed by the skimmer in a lump. From one to two handfuls to 100 lbs. of brass will be found satisfactory. If the salt is added before the copper is molten it is apt to attack the crucible and cause pin holes.

Query.

Phosphor-Bronze Trouble.

I am making some phosphor-bronze sleeves or plungers, 6 ft. 6 in. long, tapering from 4 in. to 15 in. and of 7/8 metal, the 15 in. end being cast solid, 1¼ in. thick. I have been melting the metal in small cupola, having nothing else to melt the amount required to cast; but find great difficulty in casting free from gas cavities. These are more pronounced near the top. I pour the casting on end, in dry-sand moulds, and gate at the bottom of 15 in. end. No defects are noticeable until the castings are turned, the cavities being close to the skin of the casting.—R. W. W.

Answer.—We are afraid you will continue to experience trouble with this work so long as you melt in a cupola. We have never known really good castings from cupola-melted metal, though they may have been produced. You might, however, try pouring the mould in a sloping position, gating at the bottom with a horn gate.

We invite the opinion of our readers on this problem.

Continuous Blue-Printing Machine.

We illustrate herewith an apparatus, by The Westinghouse, Cooper-Hewitt Company, Limited, 80, York Road, King's Cross, N., for the production of blue prints for works. The stationary type of the apparatus consists of a transparent glass cylinder, on the surface of which the tracing and sensitised paper are placed. A cloth band holds them in close contact with each other and with the surface of the cylinder. One or two Cooper-Hewitt tubes of high candle power are placed inside the cylinder. The horizontal cylinder is on a table at a convenient height, and the operator is able to work with great speed and much less fatigue. This arrangement is possible owing to the use of Cooper-Hewitt Lamps which are in the form of a long tube. The act of closing the switch causes the mercury in the tube to vapourise, and this luminous vapour emits a light very rich in actinic rays, and

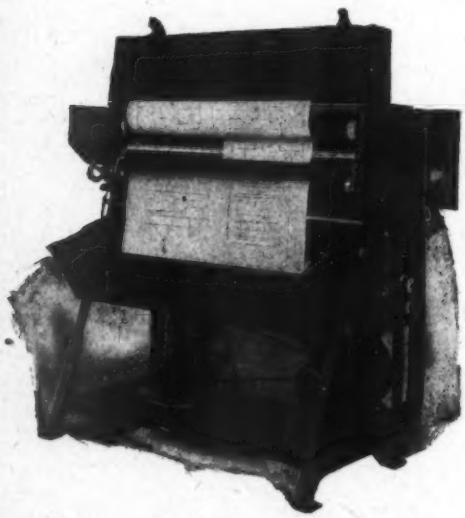


FIG. 1.—CONTINUOUS BLUE-PRINTING MACHINE.

especially suitable for all reproduction processes. With electricity at 1d. per unit, an outfit costs three farthings per hour to operate. The luminous length of the tube exceeds the printing length of the cylinder, thus ensuring uniform illumination of the surface, and consequently a uniform print.

In the continuous type a continuous roll of printing paper is fed on to a cylinder of transparent glass inside which are one or more Cooper-Hewitt tubes. The cylinder is supported in a series of endless belts carried on four rollers—one of which transmits the drive. The cylinder rotates with the belts, and as there is no relative motion between the belts and the cylinder there is no possibility of "creep" between the paper and the tracing. The tension of the belts and small diameter of the cylinder ensure tracing and paper being held in a close contact, and perfectly sharp prints are obtained. By pressing a pedal the cylinder may be immediately thrown out of gear and then turned either way by hand. This is a great advantage when old and very much creased tracings are being used, or when a small print is being made from a large tracing. In the latter case, the tracing on the cylinder may be revolved to the desired point and the paper inserted in its correct position. By releasing the pedal the rotation of the cylinder continues at the desired speed (up to 30 ft. per minute), and printing proceeds in the usual manner. The machine is

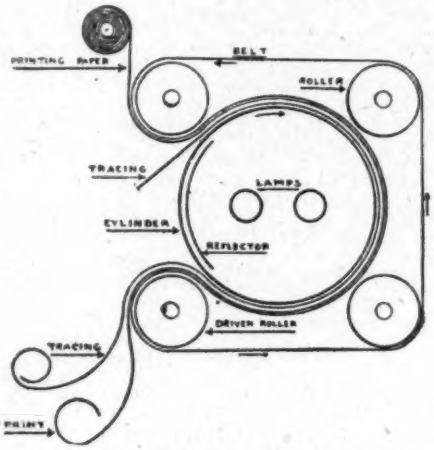


FIG. 2.—DIAGRAM OF CONTINUOUS BLUE-PRINTING MACHINE.

driven by a motor through a variable speed gear. Any length of print can be made, or a number of small prints can be fed into the machine in the same way as paper is fed into a printing machine, thereby enabling a considerable amount of work to be got thorough quickly.

HEAT TREATING STEEL RAILS.—The heat treatment of steel rails, using the usual methods of treating steel, has not been successful owing to the varying temperatures at which the rails leave the rolls, the great and varying speed at which they travel, and the variation in weight, and therefore mass, to be cooled. This statement is made by Mr. C. P. Sandberg, in discussing the claims of his patent for a method of treating steel. The inventor has found that "if carbon steel, while at a temperature above the critical, is treated with an elastic fluid such as air or steam, or a very finely divided or atomised water or brine, or both elastic fluid and liquid together, delivered on the surface of the steel so as to cool it moderately rapidly, or quicker than it would take place normally, but not so swiftly as to produce a brittle or martensitic structure, the desired hard and tough sorbitic structure can be secured without double heating or reheating, or the formation of fine cracks." Mr. Sandberg avails himself of the heat existing in the rail after the completion of the rolling operation. While the rail is still above the critical temperature, steam or air, or a mixture of air and steam, is caused to impinge on the head of the rail for a time varying with the weight and section and the temperature. The operation is so conducted that the rate and degree of cooling are such that when the cooled upper portion of the head is reheated by any heat retained in the upper part not yet cooled, or cooled more slowly, the hard and tough structure produced is retained and the upper part is of great hardness combined with toughness, the other portions of the section being practically unaffected. It is claimed that no reheating, before and after the rapid cooling, is necessary.

Alloys to Withstand Internal Air Pressure.*

By S. D. Sleeth.

Density and strength are the two qualities that go to make up a metal suitable for the retention of air or other gases under pressure, and while strength may be secured through proper design, density is elusive. This leads us to the conclusion that there can be no hard and fast rule whereby density can always be obtained, probably because of the many variables that enter into the process. To enumerate some of these variables, there is the design of the article to be cast, the design of the pattern with reference to its position in the flask, composition of the alloy, the treatment of the metal in the furnaces, and the temperature of the metal when being poured.

The design of the article to be cast has a very important bearing upon the ultimate success of the casting. The designer should bear in mind the desirability of having all cross sections of approximately equal thickness in order to prevent draws at heavy portions. If this is not possible, access to all large sections should be allowed for the use of chillers to prevent such draws. If the cored cavities are large the cores will, themselves, act as chills. Fillets should be as small as possible in order that excessive masses of metal shall not be concentrated at one point.

In laying out patterns, the patternmaker must be governed by several things. He must know what chillers are to be used so that large chilled surfaces may be placed in a vertical position in order to prevent the metal kicking off these surfaces. He must know what parts are to be clean, such as valve seats, etc., and to what parts loose sand may be allowed to flow if any be found in the mould. Such unimportant parts should be placed high in the cope so the loose sand will flow to them on top of the metal. A clean mould, however, is absolutely essential to good tight castings. An exceptionally clean casting may be obtained by gating it from another casting which will itself take all the dirt.

On the use of chillers might be stated as an almost universal law:—Use chillers on all enlarged sections in close proximity to smaller sections and connected thereto. If the sections are exceptionally large, use a sinking head on top of the large sections. Gate the moulds with a heavy upright pouring gate as near to the pattern as possible. The gate leading from the pouring gate to the pattern should be made large at the pouring gate, and then reduced sharply into the pattern. If it is large where it joins the pattern, in all probability it will show a draw in the casting at the gate. As a rule, it is better to gate in a light part of the casting than in a heavy portion. If a sinking head be used it should be placed on the heavy part.

As regards the alloy to be used, the following compositions have been tried and found satisfactory for the purpose intended:—

	No. 1.	No. 2.	No. 3.
	Per cent.	Per cent.	Per cent.
Copper	72.50	82.00	83.00
Tin	1.75	7.50	11.50
Zinc	19.25	4.75	4.00
Lead	6.50	5.75	1.50

No. 1 is used for ordinary castings, such as cocks, pistons, bushings, etc. This alloy is easily machined, but is not intended for use with very high pressures. No. 2 and No. 3 Alloys are intended for use with high pressures and are harder to machine in proportion.

The treatment of the metal in the furnaces is of vital importance. If proper allowance for oxidation of zinc, etc., is not made the alloy intended will not be produced. Furthermore, the metal must be taken from the furnace as soon as it reaches the proper heat, for if allowed to soak in the furnace, it will take up gases and the castings made from it may be porous. In certain packing-ring mixtures we consider this item so important that we use an alarm clock to insure the metal being poured off at exactly the proper moment.

The temperature at which the metal should be poured into the moulds is important. If poured too cold it is almost impossible to obtain solid castings, especially at the gate. On the other hand, if poured too hot, the castings may be porous throughout. Great care must be taken to see that no aluminum gets into the mixture, as a very small percentage of it will cause the castings to leak. Antimony and iron will do the same, but not to so great an extent. Aluminum has a very peculiar action on the metal. The castings will look solid and will not show a draw, but when put under pressure will leak all over. It is one of the most dangerous metals around the brass foundry. Antimony does not act as quickly as aluminum, but has about the same effect if used long enough in the mixture. With a small percentage it may seem to do no harm, but if used until it is mixed with all returned material, such as turnings, gates, etc., the castings will become porous.

* Paper presented at the Annual Meeting of the American Institute of Metals, September, 1916.

The Decimal System.

Before the British Association last month, Dr. G. B. Hunter, in the absence of Sir Richard Burbidge, read a Paper on the subject of "The Decimal System in Currency, Weights and Measures," explaining that the views he expressed were largely those of Sir Richard Burbidge. Dr. Hunter discussed the subject from the point of view of commercial competition, particularly in the period following the war. He said that to obtain openings for British goods we must use the metric system. Our Overseas Dominions were ripe for the change. Amongst the benefits in the home country, if the reform were adopted, he estimated a year of school period now wasted in teaching our arithmetic. There would also be a great saving in book-keeping and clerical work. In shipbuilding they had adopted the decimal system for all their calculations, and without it they could not have succeeded. The advantages of being in line with those with whom we were to do business far outweighed any objection. In regard to coinage, the line of least resistance would be to retain the pound and the florin. A beginning, he considered, should be made without delay. The simplest change was of the coinage, and they might begin the reform of weights and measures which were in common use in our commercial dealings with foreign countries.

Mr. Gerald Stoney (President of the Engineering Section) strongly supported the change, contending that it was absolutely necessary if we were to keep our foreign trade. One firm of turbine engineers at Hartlepool had adopted the metric system throughout their works. When, however, they began to do work for the Admiralty they were compelled to use the existing system. But in practice there had been no difficulty in working the two side by side, which was a valuable piece of experience, suggesting that the change might be made gradually. For instance, engineers might be notified five years in advance, so that such things as gauges might be altered without wholesale scrapping of existing machinery.

Trade Talk.

In future all communications for Joseph Sankey & Sons, Limited, should be addressed to the Hadley Castle Works, Wellington, Shropshire.

The Bastian Electric Heating Syndicate, Limited, 185, Wardour Street, W., will, in future, be known as the Bastian Electric Company, Limited.

Mr. I. Jevons, scrap iron merchant, carrying on business at 109, Woodland Street, Smethwick, is paying a first and final dividend of 1s. 4½d. in the £.

The Council of the Leeds University, on the suggestion of the Ministry of Munitions and the Home Office, has arranged two courses of preparation for welfare supervisors in factories.

The Irlam (near Manchester) District Council have passed plans for the erection of extensive dining halls and canteens at the Partington Steel & Iron Company's works on the Ship Canal, at Irlam.

Mr. S. N. Wellington, 62, London Wall, E.C., is making an application before the Patents Court on September 27 for the benefit of Patent No. 7206/14, granted to Pierney, for walls and tuyeres of furnaces.

The partnership heretofore subsisting between Messrs. G. Johnson and A. E. Smith, carrying on business as engine specialists and motor engineers, at East Street Works, Coventry, under the style of Johnson & Smith, has been dissolved.

Messrs. J. G. Bulmer, F. C. Bulmer, S. Bulmer, and A. E. Bulmer, engineers and millwrights, Pitt Street, Newcastle-upon-Tyne, trading under the style of John Bulmer & Sons, have dissolved partnership, so far as regards Mr. J. G. Bulmer.

By the National Insurance (Part II.) (Munition Workers) Act, 1916, which came into force on September 4, the compulsory scheme of unemployment insurance is extended to certain scheduled trades and to all workpeople engaged in munitions work.

The partnership heretofore subsisting between Mary A. Tempest and F. E. Arculus, carrying on business as brassfounders, at Brooks Works, Aston Brook Street, Birmingham, under the style of James Gibson, has been dissolved. Mr. Arculus will continue the business.

Alldays & Onions Pneumatic Engineering Company, Limited, Birmingham, have forwarded a copy of their latest catalogue of smiths' hearths, heating furnaces, blast-pipe connections, etc., which should be of considerable interest to the trade, as it includes a variety of plant.

According to the report of the Steel Company of Scotland, Limited, the work which was in progress to improve and extend the blast-furnace plant of the Appleby Iron Company, Limited, is now completed, and the production of pig-iron is being satisfactorily carried on.

It is officially announced that Messrs. Harland & Wolff have secured from the Belfast Harbour Board 40 additional acres of land for shipbuilding purposes at a rental of £2,500 per annum, and that Messrs. Workman, Clark & Company, Limited, are negotiating for further land for increasing shipbuilding slips.

At Warrington last month, the Pearson & Knowles Coal and Iron Company, Limited were fined £25 on five summonses for unlawfully employing men of military age without badges or exemption certificates. It was stated in defence that it was an almost insuperable task in large works to obtain satisfactory replies from all employees.

Damage to the estimated extent of £500 was done by a recent outbreak of fire in the premises of Messrs. Allan, Ure & Company, Springbank Iron Works, Keppochhill Road, Glasgow. Portions of the roofs of the fitting shop and the moulding shop and a timber partition were destroyed. The gas-engine house was also affected.

The Ministry of Munitions makes the announcement that the price of ferro-tungsten is officially fixed at 5s. 6d. per lb. of tungsten content, and of tungsten powder at 6s. 3d. per lb., based on ore at 60s. per unit. The price of the product is on a sliding-scale, which rises or falls 1d. per lb. with each variation of 1s. per unit of the ore.

Messrs. M. B. Wild & Company, Limited, Birmingham are engaged upon important extensions to their Nechells Works. These, which include the building of a new pattern shop and stores, the erection of a plating shop, for building up drums, etc., and a considerable addition to the machine and fitting shop, will more than double the present floor space of the works.

The business of the London Electron Works, Limited, offered for sale by the receiver for the debenture-holders of the company, has been acquired by Messrs. George Cohen, Sons, and Company, of Commercial Road, London, E. The works, which dealt with old tins and similar waste produced in London, were closed shortly after the outbreak of war, but will be re-opened in a few months as an all-British concern.

Armstrong, Whitworth of Canada, Limited, the Canadian branch of Sir W. G. Armstrong, Whitworth & Company, Limited, have closed a contract with the Mojave Tungsten Company for high-grade wolframite ferro-tungsten. Except for some small shipments the Canadian company has been unable hitherto to obtain any supply of wolframite ferro-tungsten. The Mojave Tungsten Company controls the only large deposits of wolframite in the United States.

The Cheshire County Council Education Committee have made arrangements with the authorities of the McGill University, Montreal, which will permit of engineering students winning Technological Scholarships in Cheshire going to Montreal to have part of their three years' training at the McGill University. It is understood that the arrangement is reciprocal, and that the McGill students will be accepted at English Universities for a portion of their training.

At the Patents Court last month Messrs. Vickers, Limited, applied in respect of a process for improving aluminium alloys by heating and chilling. The German firm of Wilm & Kronkseneider claim to hold the patent. Messrs. Vickers contended that they have the exclusive right to the patent, but being in some doubt as to their position applied to the Court. The application was made in camera, but it is understood that Messrs. Vickers are to have a licence on terms similar to those contained in an original licence held by them.

A special supplement to the "London Gazette" makes it lawful for the Admiralty or Army Council or Minister of Munitions, with a view to the more efficient or increased production of war material, to require any person to communicate to a person nominated for that purpose by the Admiralty, Army Council, or Minister of Munitions, all such particulars as may be in his possession of any invention, or process or method of manufacture, or of any article manufactured or proposed to be manufactured, and to furnish drawings, models, or plans thereof.

The Birmingham Chamber of Commerce is appealing for subscriptions with the object of providing a "House of Commerce" worthy of the city. Among those who have already subscribed we note the Birmingham Small Arms Company, £2,000; Mr. Dudley Docker, C.B. (for the Metropolitan Carriage, Wagon, and Finance Company), £1,000; Messrs. Kynoch, £1,000; Messrs. Vickers, Limited (including Wolseley Motor and the Electric and Ordnance Accessories Company), £1,000; the General Electric Company, £262 10s.; Messrs. W. & T. Avery, £250; the Hales-owen Steel Company, £250.

The Minister of Munitions announces that he has made further Orders under the Munitions of War Acts, 1915 and 1916, under which 161 additional establishments have been declared controlled establishments. The total number of controlled establishments under the Munitions of War Acts, 1915 and 1916, is now 4,212. The recent appeal made by the Ministry for men to join building labour squads has met with a fair response, but a further very large number are wanted immediately, and it is hoped that every man over military age who has the necessary physical strength will go to the Labour Exchanges and offer his services.

NOTICE is given that, at the expiration of three months, the names of the undermentioned companies will, unless cause is shown to the contrary, be struck off the Register of Joint Stock Companies, and the companies will be dissolved :—Dereham Ironworks, Limited; Engineering and Mercantile Company, Limited; F. B. Two-Stroke Engine Company, Limited; Green Engine Company (1913), Limited; Lester Engineering Company, Limited; Midland Screw and Steel Company, Limited; Turbiro Engine and Pump Company, Limited.

THE MINISTRY OF MUNITIONS has issued a new set of regulations for the protection of workers against industrial disease. The Ministry, which has for a long period availed itself of the services of a General Welfare Department, has now established another, specially concerned with the explosive-filling factories. The attitude of the Minister of Munitions is that he must prove a model employer, and that it is his duty to procure the health and well-being of those engaged in what is to-day the most vital of national trades. To this effect new rules as to the handling of explosives are being put into force; they are based solely on commonsense, on the view that air, light, cleanliness and good food are the rule for work as well as for life.

THE MINISTER OF MUNITIONS calls the attention of all manufacturers and others who have occasion to issue priority certificates under the control of output scheme described in circular letter L. 33, placing their orders in Classes A or B, as the case may be, to the importance of exercising the greatest care in giving the correct classification. The use of a wrong classification may lead to an improper diversion of labour or material from the production of munitions to less urgent purposes, and the issue of certificates is, therefore, a duty to be discharged with a due sense of responsibility. The making of any false statement or representation in a certificate is an offence against the Defence of the Realm Regulations involving very serious penalties, and such penalties have been inflicted in a recent case.

EXTENSIVE developments are projected in the shipbuilding industry at Dundee, which will permit of the building of vessels up to 600 ft. in length by the Caledon Shipbuilding & Engineering Company. As a result of the negotiations with the Harbour Trustees the company are now building a jetty 250 ft. in length and 110 ft. breadth in front of their present shipyard, and are also putting in foundations for an electric crane capable of lifting about 130 tons. This work is being carried out in ferro-concrete by the Yorkshire Hennebique Company. At the west end of the present Caledon yard two additional ships capable of dealing with average sized vessels are being constructed, and ground to the west formerly used as a timber yard has been leased with a view to extensions which will enable the company to build the large vessels referred to.

IN consequence of the heavy increase in the number of their employées, particularly female, Vickers, Limited, have found it necessary to pay more than usual attention to the question of housing and welfare. In one district the company have organised in a rural area a housing scheme affecting some 4,000 workers. The scheme has been very successful. Public buildings and schools were secured with the assistance of the Ministry of Munitions, and about 200 private houses taken over. These houses have been renamed "Vickers' Hostels," numbered serially, and divided into various districts. The larger houses have been prepared for the accommodation of single men, where each man has his own separate cubicle, while smaller houses have been let off to married couples, and in some cases divided into flats. In addition, the firm supplies and cooks the food of the colony, and as a result the cost of living in the district has been reduced.

Details of the latest scheme of the Ministry of Munitions for expediting the output of shells and guns, the enrolment through the Labour Exchange of what is called a Mobile Building Labour Squad, have been officially published. The idea is to speed up the completion of munition factories which are now in course of construction. The enrolment will take place through the Labour Exchanges, and the men will receive the pay of the particular job on which they are employed prevailing in the district in which they enrol or in the district to which they are sent, whichever may be the higher. Their travelling expenses will be paid to and from the place to which they are directed by the Ministry of Munitions to go, and they will have free accommodation or an allowance of a shilling a day. The men who are accepted will be required to sign on for six months or the duration of the war, and at the end they will receive certificates indicating the services that they have rendered to their country. If in employment when they are enrolled the men accepted will be guaranteed three months' employment certain.

IN the Patents Court on August 24 an application was made by counsel for a licence on behalf of a client to use two patents in the name of Dr. Goldschmidt, of Essen, for alumino-thermic processes. Counsel opposed on behalf of Thermit, Limited, and objected to the jurisdiction of the Board of Trade. He stated that by agreement the right to these patents was vested in Thermit, Limited, and that within the last fortnight pursuant to an order of the Board of Trade the Public Trustee entered into an agreement to sell the whole of the shares in Thermit, Limited, which hitherto had been held by alien enemies, to the Birmingham Metal & Munitions Company, Limited, the consideration for the sale being £19,500. That sum had actually been paid to the Public Trustee. The shares had been transferred, but the registration of the transfer since the transaction was completed only a day or two ago had not yet been made in the books of the company. After arguments on both sides the Court adjourned the application in order to have time to consider whether the jurisdiction of the Board of Trade was ousted because of the British nature of the Birmingham company, and also to determine the construction of the agreement between Thermit, Limited, and the Birmingham company.

IT is officially notified that the following changes have recently taken place in the office organisation of the Ministry of Munitions: Sir Glynn West will in future be directly responsible to the Minister for the conduct of his Department, which deals with the manufacture of shells and their components. His title will be Controller of Shell Manufacture. Mr. H. Fowler will therefore be designated Deputy - Controller. The branches dealing, respectively, with the supply of metals, coal, and other materials, and with machine tools, will work immediately under the Director-General of Munitions Supply. Mr. Leonard Llewelyn and Mr. Alfred Herbert thus become Deputy Directors-General. Mr. John Hunter has become responsible for the branch which deals with the production of steel. At the Ministry of Munitions last month, Mr. R. H. Carr, assistant general secretary, pointed out to a number of Press representatives, with reference to the acquisition of the Constitutional Club and other premises, that the increased output of munitions necessarily meant increased work at headquarters. The original practice of the Ministry of ordering complete shell had now been changed, and the various components of which each shell was comprised were each bought separately. This was in the interests of economy, and of course involved a large addition to the headquarters staff, inasmuch as the purchase of each component part of a shell meant separate contracts, involving separate negotiations. In addition, various services were constantly being transferred to the Ministry, and there was constant change in the design of various munitions of war, all necessitating a larger staff.

SIR J. S. RANDLES, M.P., speaking at the annual meeting of the Workington Iron & Steel Company, Limited, last month, in referring to the future, said he was quite sure that the iron and steel industry must be regarded, not as the interest of a few individuals, not as the mere property of certain persons who took an interest in a particular manufacture, but as part of our national assets, as part of our national industry, and that it should have something of the care and consideration which an industry that to a large ex-

tent controlled the destinies of the nation deserved. But for that superiority in the manufacture of iron and steel which was attained by the Germans prior to the war, Germany would never have been able to wage war against the other Powers of Europe. They had not only taken their place as the largest manufacturers of iron and steel in Europe, but they had developed their manufactures under Government auspices to such an extent that their total production was greater than the whole of the Allied production put together. In that position they were able to challenge the rest of Europe. He did not think we should allow that position to recur, and therefore he was of opinion the policy indicated at the Paris Conference and specifically approved by the Prime Minister in the House of Commons should be adopted and carried out, as the Government had given emphatic pledges that it should be. He did not believe they could put any limit as to the possibilities of the iron and steel industry in this country in future. Germany made much of Krupps for many years before the war. No effort that the Government of Germany could put forth to enable Krupps to secure markets, to produce under the most advantageous conditions, and to distribute under the most advantageous conditions was omitted. Krupps were pampered and petted in every way that was possible, not because of Messrs. Krupps, but because of the national interests that were at stake. The Government here, he hoped, would appreciate in future that the interests of the iron and steel industry throughout the length and breadth of this country were so regarded and should be so ensured that both capital and labour should find its full reward.

Industrial Fatigue.

At last month's meeting of the British Association, Professor J. H. Muirhead presented the second interim report of the Committee upon the question of "Fatigue in Industry."

Dr. G. B. Hunter, while agreeing that the question of fatigue or over-fatigue had some importance, said that there were some much more important matters which needed inquiring into, and that the importance of the question of fatigue had been very much exaggerated. His statistics showed that accidents were more numerous during the first than the latter half of the day, and, curious to say, there were more accidents on Saturday mornings than any other morning, but on Mondays, after the Saturday and Sunday rest, there were more accidents than on any other day of the week. If men combined hard work with drinking whisky, then over-fatigue might and did come in. Men who did not take drink worked longer hours in his works and did not suffer in health or complain of over-fatigue. It was the men who took drink—he did not mean drunkards, but who took a certain amount of drink—who found that they were not able to work long hours, and who complained of over-fatigue and who did not come in on Mondays, and sometimes not on Tuesday. If men worked harder they would feel very much less fatigue. The effort to work slowly was really very fatiguing. As a matter of fact there was a great deal of "coddling" going on and it diverted attention from real evils. He had worked harder in his time than any of his workmen, and he had not suffered in health.

Sir Thos. Oliver, the well-known specialist on industrial diseases, followed, affirming that industrial fatigue was entirely the outcome of recent conditions of labour, and that it played an important part in the number of accidents that occurred. Housing conditions and home surroundings influenced the workers considerably. It was necessary that men who had been working all day, whose brain cells and nerve cells contained waste product, should throw these off before next morning. How could this be accomplished in a small, stuffy room or a crowded house with windows closed? In these circumstances, working men became prematurely old.

Hours of Labour in Munition Works.

A White Paper was issued on September 19 giving, in the form of an appendix to the Report of the Health of Munition Workers Committee on Hours of Work, statistical information concerning the output in relation to hours of work, prepared by Dr. H. M. Vernon. The memorandum deals with the results obtained from a group of workers whose working hours were reduced from 74.3 to about 60 per week, and states that probably the 60 hours are still too many to give the best total output, but they justify the conclusion that in order to attain a maximum output women engaged in moderately heavy manual labour should not work for more than 60 hours per week.

The Committee further expresses the opinion that a reduction of the working hours to 56 per week would have no adverse effect on output, and that there can be little doubt that this number of hours is the absolute maximum for the type of work under consideration. For women engaged on light labour the Committee thinks that the best number of hours is about sixty-two. As regards men engaged in heavy labour, it is shown that after a reduction of 10.4 in the hours of work, though the operatives took a long time to adapt their rate of production to the shorter hours, the total output was increased by 13 per cent. above that at the old hour rate. In regard to youths, the effect of the long hours was most marked; the output was no less than 42 per cent. greater in eleven weeks after the hours of labour had been reduced from 70.3 to 57. With regard to men and youths engaged on light labour, experiments showed that to attain a maximum output 70 hours or more per week must be worked. One of the conclusions of the Committee is that though stern necessity may compel long hours of labour on the part of many munition workers, provided maximum output is maintained, the shorter the times for which they are shut up in the factories the better their chances of health and happiness.

Applications for Patents.

The names of communicators are printed in Italic type. A new number will be given when the Complete Specification is accepted.

Aitken, T. W. Crucible furnaces for melting metals. 11,823. August 21.

British Thomson-Houston Company (*General Electric Company*). Electric furnaces. 12,147. August 28.

British Thomson-Houston Company (*General Electric Company*). Electric furnaces. 12,210. August 29.

British Thomson-Houston Company (*General Electric Company*). Electric furnaces. 12,279. August 30.

Chesterman, W. Manufacture of steel and its alloys. 12,018. August 24.

Denton, J. J. Producing and controlling high temperatures in furnaces. 11,844. August 21.

Hall, I. Furnaces. 11,507. August 15.

Hall, I. Casting metal, etc. 11,701. August 18.

Keith, G. & J. Art of lining crucible furnaces. 11,853. August 21.

Leeds Fireclay Company, and Barrett, M. Process for preventing disintegration of refractory materials. 11,751. August 18.

Rennerfelt, I. Electric furnace. 12,396. September 1. (Sweden, September 8, 1915.)

Smallwood, A. Furnaces for heating hardening, tempering, annealing, carbonising, etc., 12,200, 12,201. August 29.

Soc. Electro-Metallurgique Française. Electric furnaces. 11,623. August 16.

Stahlwerke R. Lindenberg Akt.-Ges. Manufacture of steel alloy. 11,628. 11,629. August 16. (Germany, January, 25.)

Stahlwerke R. Lindenberg Akt.-Ges. Manufacture of steel alloy. 11,664. August 17. (Germany, February, 26.)

Turner, A. Electro-magnetic pneumatic furnace. 11,564. August 16.

Turner, W. L. Manufacture of ferro-alloys. 11,502. August 15.

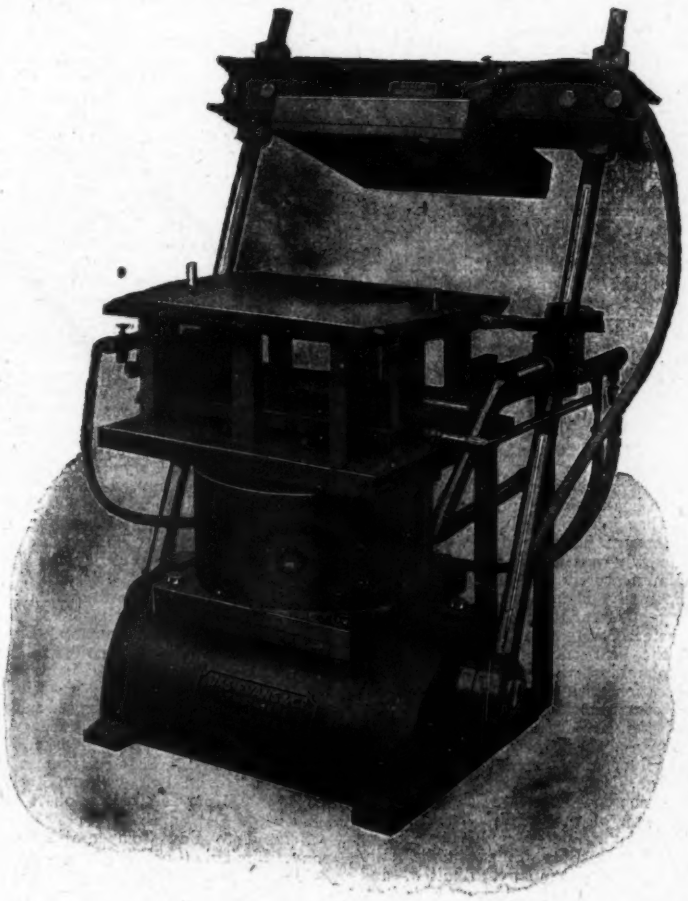
Wade, H. (*Compagnie Italiana Bronzi Speciali*). Apparatus for measuring deformations of test pieces. 11,630. August 16.

West & Company, A., and West, A. Electric lifting magnets. 11,812. August 19.

MOULDING MACHINES

OF EVERY DESCRIPTION.

Pneumatic, Hydraulic, Jar Ramming, & Hand Power.



JAMES EVANS & CO., BRITANNIA WORKS,

BLACKFRIARS, **MANCHESTER.**

Personal.

THE late Mr. Hugh Miller, iron merchant, etc., 691, Shields Road, Glasgow, left estate valued at £6,523.

MR. FREDERICK ANDREW, for 16 years chairman of Robey & Company, Limited, Lincoln, left estate of the value of £213,396.

THE late Mr. T. E. Dodgson, a director and general manager of the Parkgate Iron and Steel Company, Limited, left £16,282 gross.

DR. W. R. JONES has been in Tavoy, Lower Burma, inquiring into the production of wolfram, on behalf of the High Speed Steel Alloys, Limited, of Ditton Road, Widnes.

MR. ROBERT YOUNG, formerly of Glasgow, has been re-elected general secretary of the Amalgamated Society of Engineers, and Mr. Glennie, assistant general secretary.

MR. J. F. CHAMBERS, of the Elms, Daybrook, Nottingham, has been appointed secretary of the Nottingham Society of Engineers, in place of Mr. H. G. Price, who recently resigned.

SIR FRANCIS LEY, Bart., governing director of Leys Malleable Castings Company, Limited, Derby, who died on January 7, left unsettled estate of the value of £448,424, the net personalty being £321,981.

MR. F. DUDLEY DOCKER has been elected president, and Sir William Peat chairman, of the Federation of British Industries Association, which has been established as a central organisation of manufacturing interests.

DR. W. H. WELCH, president of the National Academy of Science (U.S.A.), and Dr. G. E. Hale, foreign secretary, are at present in London to study the work of the Advisory Council for Scientific and Industrial Research.

MR. DANIEL BOWIE has been the recipient of presentations from the workmen of the Workington Iron & Steel Company, Limited, as a token of esteem after 35 years' service. He recently retired from the position of engineer at the Derwent blast-furnaces.

AT the request of the Minister of Munitions, Mr. Charles Ellis, a director of John Brown & Company, Limited, undertook important Government war work, and in consequence he has temporarily retired from the board. Lord Pirrie has joined the directorate.

SIR CHARLES H. BEDFORD has been appointed general secretary of the newly-constituted Association of British Chemical Manufacturers. The business of the association is temporarily being carried on at the offices of the Society of Chemical Industry, Broadway Chambers, Westminster, S.W.

THE directors of the Weardale Lead Company have established two scholarships with the object of linking-up technical education with practical work. These scholarships are to commemorate the services of Mr. G. Richardson and the late Mr. J. Cameron Swan, directors of the company, the former to be connected with the Royal School of Mines, and the latter with the Armstrong College, Newcastle.

MR. W. COCKS who succeeded the late Mr. W. Jones, J.P., as general manager of the Cardiff Channel Dry Docks & Pontoon Company,, Limited, and its subsidiary undertakings, namely, the Bute Shipbuilding, Engineering, and Dry Dock Company, Limited, and Tredegar Dry Docks and Wharf Company, Limited, in August, 1913, has now been elected managing director of the undertaking.

MR. E. J. FOX is resigning the position of London manager of Messrs. Stewarts & Lloyds, Limited, in order to take up the position of general manager to Messrs. the Stanton Iron Works Company, Limited, near Nottingham, with a seat on the board as managing director. Mr. Fox succeeds in March next Mr. J. A. Longden, whose services will, however, be available to the company as he remains a member of the board of directors.

THE late Mr. J. H. Boolds, for 12 years (until 1912, when he retired) shipbuilding director of Messrs. Vickers, Limited, formerly a director and manager of Messrs. Raylton, Dixon & Company, of Middlesbrough, President of the Shipbuilding Employers' Federation in 1911, a member of the Institute of Naval Architects, the Worshipful Company of Shipwrights, and son of the late Mr. Henry John Boolds, for many years Lloyd's Chief Surveyor at Newcastle, left estate valued at £14,465.

MR. R. B. HODGSON has been appointed by the directors of Ashmore, Benson, Pease, & Company, Limited, Stockton-on-Tees, to the position of general manager. Mr. Hodgson for the last five years has been acting as manager, and previous to this was works manager for three years. During the time Mr. Hodgson has been with the firm many large and important private and Government contracts have been successfully carried out. The works at Stockton have also been considerably enlarged.

Air Raids and Bombardments.

For some considerable time negotiations have been proceeding between the employers and representatives of the British Steel Smelters' Society on the question of the payment of compensation, as though the Workmen's Compensation Act applied, in respect of any member of the society injured or killed in consequence of enemy bombardments by air or by sea. The matter is dealt with in the monthly report of the society, in which the secretary says that as regards a number of firms the matter is not yet definitely settled, but the following have come to a decision:—

Agreed to Pay Compensation.—Stewart & Lloyds, Limited; Steel Company of Scotland, Limited; Lanarkshire Steel Company, Limited; P. and W. McLellan, Limited; Consett Iron Company, Limited; Skinningrove Iron Company, Limited; Cargo Fleet Iron Company, Limited; South Durham Steel & Iron Company, Limited; Palmers Shipbuilding & Iron Company, Limited; John Spencer & Sons, Limited; Bolckow, Vaughan & Company, Limited; North-Eastern Steel Company, Limited; Darlington Forge Company, Limited; Ashmore, Benson, Pease & Company, Limited, Stockton; Craig, Taylor & Company, Limited; William Gray & Company, Limited; Seaton Carew Iron Company, Limited; Henry Bessemer & Sons, Limited; Monksbridge Iron & Steel Company, Limited; Leeds Forge Company, Limited; Bowesfield Steel Company, Limited; Parkgate Iron & Steel Company, Limited; Frodingham Iron & Steel Company, Limited; Steel, Peech & Tozer, Limited; Samuel Fox & Company, Limited; William Cook & Company, Limited; Hadfields, Limited; Shelton Iron, Steel & Coal Company, Limited; Partington Steel & Iron Company, Limited; John Butler & Company, Limited; Thomas Firth & Sons, Limited; Brown, Bayley's Steel Works, Limited; Workington Iron & Steel Company, Limited; Brymbo Steel Company, Limited; Patent Shaft & Axletree Company, Limited; Cordes (Dos Works), Limited; South Wales Siemens Steel Association; D. Colville & Sons, Limited; Round Oak Iron & Steel Works, Limited; Jonas & Colver, Limited; Robert Royes & Company, Limited.

Refused to Pay Compensation.—Cochrane & Company, Limited (Cochrane Grove Branch); Cleveland Bridge & Engineering Company, Limited; Lancashire & Yorkshire Railway Company; Smiths Dock Company, Limited; Sheffield Forge & Rolling Mills Company, Limited; Flimby & Broughton Moor Coal & Firebrick Company, Limited; Clyde Navigation Trustees; London & North-Western Railway Company (Crewe Works); North British Locomotive Company, Limited; Acme Steel & Foundry Company.

In regard to the list of refusals, the men at the Sheffield Forge & Rolling Mills are not expected to stay in the works during a raid, but in respect of the other works mentioned the men have been advised not to give any undertaking to stand by the plant. Where the employers have recognised the extra risk involved, everything possible is to be done to ensure that the plant is under reasonable control.

10 H.P. Fan and Motor.

TRADE SIROCCO MARK

High Pressure Fans

Are made in a large number of sizes from 10 in. diameter upwards.

Bulletins 2000 F. and 2028 F.

Some Points worth noting.

Owing to few wearing parts, the Fans are not liable to break down. The mechanical efficiency is high and remains so. The pressure is steady and the volume even and free from pulsations.

Davidson & Co., Ltd.,

Sirocco Works,
BELFAST.

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,

FIRE CLAY.

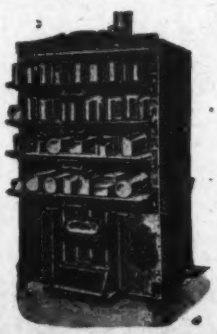
Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.

STEEL MOULDERS' COMPOSITION, SILICA CEMENT.

J. GRAYSON LOWOOD & Co., Ltd.,

DEEPCAR nr. SHEFFIELD.

Telegrams: "LOWOOD, DEEPCAR."



THE "PORTWAY"

PORTABLE CORE OVENS

For Gas or Fuel.

TESTIMONIAL.

From The Braintree Castings Co.,
Chapel Hill Foundries, Braintree, Essex.

Gentlemen,

We are very pleased with the Core Oven we recently purchased from you. We find it dries the cores quickly without burning them. It is very handy and economical to use and is altogether superior to other ovens of this type we have in use.

Will you please quote us your best price for four more like it,

Yours faithfully,
For The Braintree Castings Co.,
(Signed) W. B. LAKE, Director.

Makers: C. PORTWAY & SON, TORTOISE STOVE & PORTWAY PORTABLE OVEN WORKS, HALSTEAD, ESSEX.

Deaths.

Mr. John Clegg, formerly head of Messrs. John Clegg & Company, boilermakers, Heywood, died last month at the age of 88 years.

Mr. W. M'Kinlay, cashier to William Baird & Company, Limited, Kilsyth, died on August 26. He had been in the employment of the firm for over half a century.

Lieutenant Arthur L. Apperly, Gloucestershire Regiment, who has been killed in action, was the youngest son of the late Sir Alfred Apperly and Lady Apperly, Rodborough Court, Stroud, Gloucester, and a director of the Stroud Metal Company.

Lieutenant V. C. D. Boyd Carpenter, Royal Engineers, the youngest son of Bishop Boyd Carpenter, who was killed in action recently, studied engineering at Leeds University and at Crompton's works, and was an associate member of the Institute of Civil Engineers.

The death has taken place suddenly of Mr. H. D. Pyman, at his residence at Harrogate, at the age of 51 years. The deceased gentleman was a partner in the firm of George Pyman & Company, shipbuilders, West Hartlepool, and secretary of the Pyman Steamship Company.

Captain Arthur Kennedy, of the 23rd Australian Infantry, has died of wounds in hospital at Gottingen, Hanover, Germany, where he was a prisoner of war. He was the youngest member of Messrs. Kennedy Brothers, Limited, owners of the Roanhead Iron Mines, near Barrow-in-Furness. He was 38 years of age, and brother to Mr. Myles Kennedy, J.P., Stone Cross, Ulverston.

The death occurred at his residence in Derby on Thursday, September 14, at the age of 86, of Colonel Alexander Buchanan, who entered the engineering works of the late Mr. Andrew Handyside in the early fifties, and managed them in the late years of Mr. Handyside's life. When the undertaking was turned into a limited liability company, under the title of the Britannia Iron Works, Colonel Buchanan was appointed managing director, a position he relinquished some years ago.

We regret to announce the sudden death of Mr. David Hunter, head of the firm of David Hunter & Company, of Leeds. Mr. Hunter had spent the whole of his life in the iron and steel industry, and for many years was connected with the Barrow Hematite Steel Company. He left them some years ago to start business on his own account as an iron, steel, and machinery merchant and agent in Leeds. He was particularly successful in this venture, and made many friends throughout the country. Amongst the many agencies which he held were those of the Stirling Boiler Company, the Lilleshall Company, Limited, R. B. Tennant, Limited, and other firms. Mr. Hunter died on August 27, and was buried at Harfield Cemetery, Leeds, on Wednesday, August 30.

The death occurred recently of Mr. T. J. Drummond, of Montreal, who for many years had been prominently connected with the Canadian steel trade. Mr. Drummond became well known as a member of the firm of Drummond, McCall & Company, iron and steel merchants, Montreal, which was established in 1881 by G. E. Drummond and J. T. McCall. He organised the Montreal Car Wheel Company, the Canadian Iron Furnace Company, and the Drummond-McCall Pipe Foundry Company. He was also actively associated with the Lake Superior Corporation, of which he was president; the Algoma Steel Company, its subsidiary, at Sault Ste. Marie, Mich., the Algoma Central Railway, and the Canada Iron Corporation. He was a director of the American Iron and Steel Institute.

The death is announced of Mr. William Allday, joint managing director of Messrs. Alldays & Onions, Pneumatic Engineering Company, Limited. Mr. Allday came of an old Birmingham family, whose record as manufacturers of bellows, forges, and tools dates back to 1780. The eldest son of the late Mr. William Allday, he entered his father's business at an early age, and was followed by his brother, Mr. Edmund Allday, the concern being then known as William Allday & Sons. In 1885, owing to a development of the works, an amalgamation took place with the firm of John C. Onions (Limited), Bradford Street, who had been engaged in a similar trade which dated back to 1650. Consequent on this amalgamation the name of the firm became Alldays & Onions (Limited), with Messrs. William and Edmund Allday as the managing directors. The business progressed rapidly, and in 1885 the firm was reconstituted as Alldays & Onions Pneumatic Engineering Company (Limited), the name which it still bears.

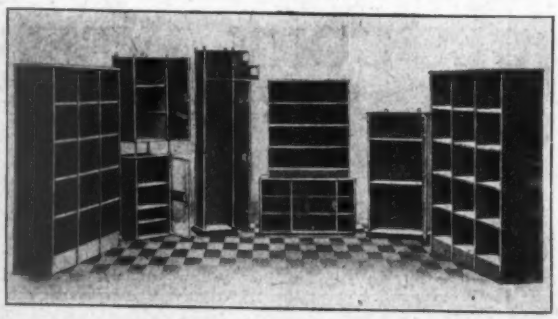
New Companies.

Novera Metal Company, Limited.—Capital of £2,000 in £1 shares, to acquire and turn to account an invention in connection with untarnishable, stainless or rustless steel, discovered by H. Brearley. Registered office :—74, Lancaster Gate, W.

H. & T. Vaughan.—Capital £65,000, to acquire business formerly carried on by G. F. Vaughan, E. Vaughan, and A. H. Vaughan, as H. & T. Vaughan, at Willenhall, Staffs, and to carry on business of manufacturers of locks, brass and iron founders, etc.

Tuck & Blakemore.—Capital of £5,000 in £1 shares, to carry on the business of ironfounders, ironmongers, tinplate workers, engineers, wire-drawers, machinists, tubemakers, manufacturers of and dealers in machinery, gas, steam and other engines, cycles, motor-cars, etc.

Burys & Company, Limited.—Capital of £200 in £1 shares, to carry on the business of ironmasters, steelmakers and converters, etc. The subscribers are:—W. F. Osborn, Snaithing Grange, Sheffield, steel manufacturer; S. Osborn, 45, Rutland Park, Sheffield, steel manufacturer; A. S. Pye Smith, 17, Endcliffe Vale Road, Sheffield, steel manufacturer; W. McKinnel, 5, Tapton House Road, Sheffield, steel manufacturer. Private company. Solicitor: A. Wightman, 14, George Street, Sheffield.



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Steel Shelving, Lockers, Bins, Cupboards, Etc.,

FOR

WORKS, OFFICES, BANKS, AND WAREHOUSES.

JAMES GIBBONS,

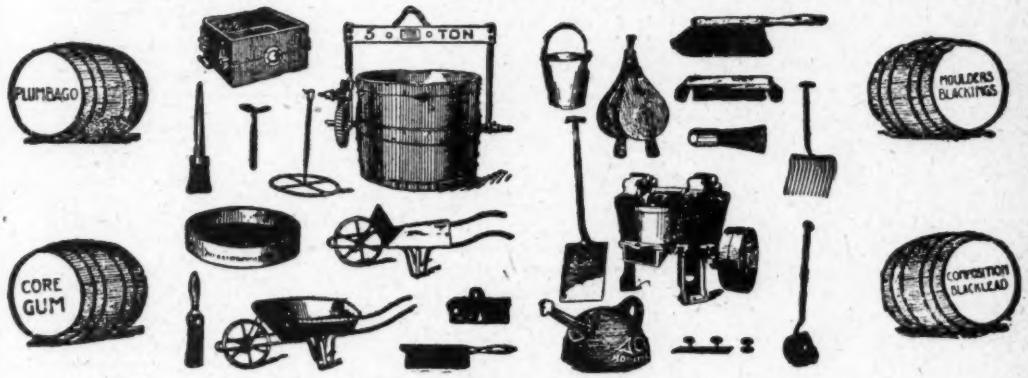
St. John's Works, WOLVERHAMPTON.

London Office: Fisher St., Southampton Row.

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.



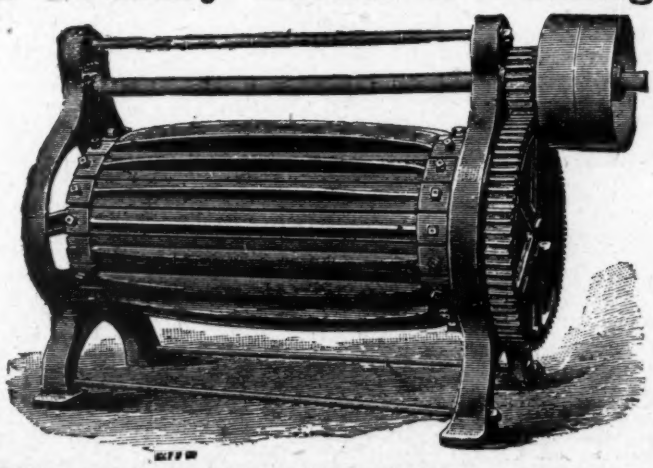
Manufacturers of all

FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

MONTHLY PRICE LIST.

The undermentioned prices, unless otherwise specified, are those obtaining at the commencement of the current month.

CONTROL PRICES.

These maximum prices of iron, steel and coke were fixed by the Government until June 30, 1916, and thereafter until further notice. Makers may sell for delivery after June 30, on the understanding that the fixed maximum prices ruling on the 1st day of any month during the period of the contract will apply to all deliveries made during that month. This intimation must not be taken to authorise any sale or purchase or other dealing prohibited under the Defence of the Realm Regulations.

Pig-Iron.

	£	s.	d.
West Coast hematite, mixed Nos., 1, 2 and 3	6	7	6
Special under 0.03 P. & S... ..	6	15	6
„ „ 0.02 „	7	0	0
East Coast hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.04 P. & S. ..	6	7	6
Special under 0.03 P & S. ..	6	15	6
„ „ 0.02 „	7	0	0
Scotch hematite, mixed Nos. 1, 2 and 3..	6	2	6
Special under 0.03 P. & S. ..	6	15	6
„ „ 0.02 „	7	0	0
Welsh hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.03 P. & S. ..	6	15	6
„ „ 0.02 „	7	0	0
Lincolnshire, basic or foundry ..	4	12	6
Cleveland, No. 1	4	11	6
„ other grades	4	7	6
Northamptonshire, forge	4	7	6
„ fdy. numbers	89/0		94/0
Derbyshire, forge	4	10	0
„ foundry numbers	92/6		96/6
Derby & Notts. basic. ..	4	17	6
Leicestershire & Notts., forge ..	4	10	0
„ „ foundry nos.	92/6		96/6
North Staffs, forge	4	15	0
„ „ foundry	4	17	6
„ „ basic	4	17	6
South Staffordshire—			
Part mine forge	4	15	0
„ foundry	4	17	6
Common Staffordshire ..	4	10	0
All mine forge	5	15	0
„ foundry	6	0	0
Warm air forge	7	5	0
„ foundry	7	15	0
Lord Dudley's silicon	8	7	6
Cold blast	9	2	6
Scotch foundry and forge—			
Nos. 3, 4, and lower grades of Monkland, Dalmellington, Eglinton, and Govan.. ..	5	14	0
Nos. 3, 4, and lower grades of all other brands	5	15	6

No. 1 quality in all cases to be 5s. per ton above these prices.

All per ton net, f.o.t. makers' works. Mers. Com. 1½%

High-Speed Tool Steel.

The maximum prices for high-speed tool steel have been fixed as follows:—

Finished bars, 14% Tung. 2s. 10d.

Finished bars, 18% Tung. 3s. 10d.

Per lb. basis. Usual trade extras for special sizes, etc. These prices are net delivered buyers' works.

The fixed prices for scrap which must be returned to steel makers' works are as follows:—

Millings and Turnings	5d
Bar Ends	6d

Both per lb. net delivered steel makers works

Ferro-Alloys

Net, Delivered Sheffield steel works.

	£	s.	d.
Ferro chrome: 4/6% carbon. Basis 60%, scale 10s. per unit Per ton	38	0	0
Ferro-chrome: 6/8% carbon. Basis 60%, scale 10s. per unit. Per ton	36	0	0
Ferro-chrome: 8/10% carbon. Basis 60% scale, 10s. per unit Per ton	34	0	0
Ferro-chrome: Specially refined, guaranteed maximum 2% carbon broken to small pieces for use in best quality crucible steels. Basis 60%, scale 32s. per unit. Per ton	120	0	0
Ferro-vanadium: 33/40% Va., per lb. of Va. contained in the alloy	0	15	0
Ferro-silicon: 45/50%. Basis 50%, 5s. scale per unit .. Per ton	28	10	0
Ferro-titanium: 23/25%, per lb. carbonless	0	1	5
Ferro-molybdenum: 70/80% Mo. per pound of Mo. contained ..	0	16	0
Ferro-phosphorus: 20/25%. Per ton	16	10	0
Ferro-tungsten: 75% to 80% per lb. of metallic tungsten contained	0	5	6
*Ferro-manganese 80%	25	0	0
„ export	30	0	0—40	0	0

* F.o.b. Liverpool.

Non-Ferrous Metals.

	£	s.	d.	£	s.	d.
Copper.						
Standard, Cash	118	10	0	119	10	0
Three months	115	0	0	116	0	0
Electrolytic ..	141	0	0	139	0	0
Tough ..	135	0	0	138	0	0
Best selected ..	136	0	0	139	0	0
Tin.						
Standard, Cash	175	5	0	175	10	0
„ Three months	175	5	0	175	10	0
English Ingots ..	—			178	0	0
Bars	—			179	0	0
Refined	—			183	0	0
Spelter.						
American	—			58	0	0
Specials.. ..	—			—		
Hard	—			42	0	0
British	—			60	0	0
Lead.						
Soft Foreign	—			32	0	0
English	—			33	0	0
Antimony.						
Regulus	—			95	0	0
Aluminium.						
Virgin Metal 98/99% per ton	155	0	0	200	0	0

Phosphor Bronze.

Ingots.	Per ton.
Alloy No. I. or II	—
III., IV. or V.	—
VI. or VII.	—
VIII.	—
XI.	—
Cast Strips and Ingots.. ..	—
Castings.	**Per lb.**
I. or II.	—
III. IV. or V.	—
VI. or VII	—
VIII.	—
XI.	—
No. VII., Chill, Cast, Solid ..	—
„ Cored Bars	—

Delivery 2 Cwt. free to any town.

10 per cent. Phosphor Copper .. 35/- above price of best selected copper.

15 per cent. Phosphor Copper .. 40/- above price B.S.

Phosphor Tin (5 per cent.) .. £23 above price of English Ingots.

(Phosphor-bronze prices supplied by Charles Clifford and Son, Limited, Fazeley Street Mills, Birmingham).

***Chromium (Metallic).**			
98/99% purity, per lb. —	0	5	9
***Nickel.**			
In cubes, 98/99% purity Per ton	220	0	0

Nickel Silver.

	per lb.
Ingots for raising	2/0 to 1/6
Ingots for Spoons and Forks ..	2/0 to 1/5½
„ rolled to spoon size ..	2/1½ to 1/7

***Tungsten Metal Powder.**			
96/98% purity.. per lb. ..	0	6	3
***Molybdenum Metal.**			
96/98% purity.. per lb. ..	—		
***Cobalt Metal.**			
97% purity .. per lb. ..	0	7	6
Quicksilver.			
75 lb. bottle	17	13	9

* Net, Delivered Sheffield Works.

Scrap Iron and Steel.

	s.	d.	£.	s.	d.
Cleveland.					
Steel scrap, heavy melting..	110	0	—		
Iron scrap cast (cupola metal)	80	0	85	0	
London (f.o.b.).					
Heavy steel			85	0	
Light „			45	0	
Heavy cast			80	0	
Control Prices.					
Heavy Steel Melting Scrap ..			5	10	0
Turnings and Borings			2	15	0

Per ton delivered Buyers' Works.

Non-Ferrous Scrap.

London merchants quote the following prices for scrap metal, delivered London, and subject to market fluctuations:—

	A. Joseph. £	s.	d.
Hy. Electrolytic Copper Scrap ..	130	0	0
Hy. Selected Scrap Brass ..	74	0	0
Hy. Tinned Copper Wire	112	0	0
Best Selected Gunmetal Scrap ..	85	0	0

Re-melted Ingot Lead 30s. under English Lead price on date of order.

Stocks.

Metals.	Tons.
Copper, Europe and afloat	15,494
Tin, London, Holland, U.S.A. and afloat	19,648

Coke.

	s.	d.	s.	d.
Middlesbrough.				
Gas Coke	32	6	35	0
Glasgow.				
Foundry Coke	—		42	6
Furnace Coke	31	0	—	
Gas Coke	—			
London.				
Welsh or Durham Foundry, d/d London Stations in truck	45	6	53	0
Ditto, d/d Birmingham Stations	44	0	46	0
Yorkshire, d/d London Stations, in truck	42	6	—	
Ditto, d/d Birmingham Stations	39	6	—	

CONTROL PRICES OF COKE.

	s	d.
Durham and Northumberland blast furnace	28	0
„ foundry	30	6
South Yorkshire, West Yorkshire, Lancashire, and Midland Counties blast furnace	25	8
South Wales blast furnace ..	30	0

All per ton net. f.o.t. ovens.

SITUATIONS VACANT AND WANTED.

JUNIOR INSPECTING ENGINEER, age 21 to 25, wanted by large firm of general engineers in the Midlands, to inspect small Iron and Steel Forgings, Malleable and Grey Iron Castings, Munitions of War. Must have previous shop experience. Ineligible for Army preferred.—Apply, giving full particulars, experience, age, salary required, to your nearest Labour Exchange, quoting No. 2444.

MOULDERS (General) required for immediate Government work. Experienced men used to high class petrol motor work. Good wages and prospects; War Bonus and overtime. No man on Government work will be engaged.—Write or apply in first instance to your nearest Board of Trade Labour Exchange mentioning this paper and No. A. 2327.

WANTED, Foreman for Foundry. State age and experience. Persons employed on Government work need not apply.—Box 840, Offices of *The Foundry Trade Journal*, 165, Strand, London, W.C.

CLERK required for Foundry Office. Persons employed on Government work need not apply.—Write, stating age, experience, etc., to Box 842, Offices of *The Foundry Trade Journal*, 165, Strand, London, W.C.

NOTICE.

SOUTH-WESTERN
POLYTECHNIC INSTITUTE,
Manresa Road, Chelsea, S.W.

Department of Chemistry and Metallurgy.

Head of Department:
J. B. COLEMAN, A.R.C.S., F.I.C., F.C.S.

Lecturer in Metallurgy:
W. A. NAISH, A.R.S.M., A.I.M.M.

METALLURGY.

DAY AND EVENING COURSES commence September 25th, 1916. Pyrometry and Metal Analysis, Engineering Metallurgy, Metallography. The work is suited to the requirements of Metallurgists, Assayers. Special facilities are arranged for individual work in any other branch of Metallurgy, such as Assaying, Mechanical Testing and Research.

For fees and further particulars apply to the Secretary (Room 65).

Telephone: 899 Western.

FOR SALE AND WANTED.

SURPLUS PLANT FOR SALE.

ONE Patent Horizontal Sand Mixer, fitted with special oscillating cover, 2 grids, and 3 sets of beaters. Ball bearings to main shafts. Capacity 3 to 4 tons per hour. Complete with countershafts and belt striking gear. By the London Emery Works Company. In perfect condition, equal to new.

1 Flat Table Hydraulic Moulding Machine, table fitted with 4 lifting pins and arranged to take moulding boxes 50in. by 17½in. Complete with wooden rammer blocks to press head. By London Emery Works Company. Equal to new.

1 ¾in. Hydraulic Stop Valves, complete with flange and joint washers.

42 Moulding Boxes, 50in. by 17½in., with planed faces.

2 Iron Pattern Frames for plaster blocks.

42 Moulding Boxes, 26in. by 21½in.

Also a quantity of hydraulic piping, ¾in. and 1¼in., fitted with T connections.

GEO. HATTERSLEY & SONS, LIMITED, Keighley.

FOR SALE AND WANTED.—(*Continued.*)

ONE good Second-hand No. 2 Roots' Blower, belt-driven both ends, about 12in. pulleys, good gearing, 8 in. diameter outlet underneath, wooden vanes, ready for prompt delivery.—MARPLE & GILLOTT, LIMITED, Sheffield.

FOR SALE.—24-in. Invincible Sand Mixer, capacity 3 tons per hour, for grinding, mixing and screening foundry sands, at lowest cost per ton.—Apply, HALL, 26, Paradise Square, Sheffield.

WANTED, Sandblast Rattler, complete with air compressor, to do 5 ton per week.—Box No. 846, Offices of *The Foundry Trade Journal*, 165, Strand, London, W.C.

REFINED ALUMINIUM INGOTS

NOTCHED BARS.

SPECIFICATIONS GUARANTEED.

MIDLAND METAL CO., COVENTRY

PATTERN SHOP SUPPLIES.

Wires: "Requisites, B'ham." **J. BURN & CO.,** 'Phone: 137 Victoria.

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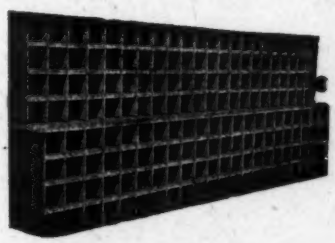
SANKEY

Fireproof Steel Storage Bins



For Workshop and Warehouse.

Write for details.

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Hadley. Salop.

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William OLSEN,
Cogan Street, HULL.

FOUNDRY MATERIALS AND REQUISITES.

Largest Stock of Straw and Wood Fibre CORE ROPINGS.

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GLUTRIN—CORE GUM.

FIRE BRICKS & CLAY
CUPOLA BRICKS.
Best Quality.

LESSEES OF DELPH AND TINTERN ABBEY BLACK AND WHITE CLAY.

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(STOURBRIDGE) Ltd.,
STOURBRIDGE.

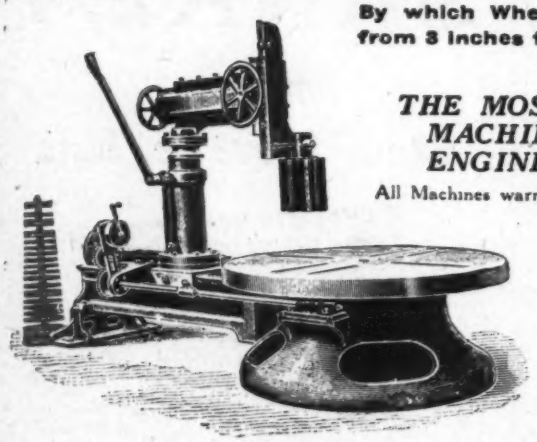
38½
McNEIL'S
PATENT UNBREAKABLE
STEEL LADLES
These Ladles are manufactured by a patented process, each from a single steel plate without weld or rivet. They are extremely light, being at the same time the strongest and most durable in the market. Ladles to contain 56 lb. of metal only weigh about 3 lbs. each. They are made of all capacities from 30 lb. to 60 cwt., with or without lips: also mounted or unmounted. They are also suitable for chemical and metallurgical processes. List of sections and prices on application to
CHAS. McNEIL, LTD.
KINNING PARK IRONWORKS,
GLASGOW
36"
32½"

CAN ALSO BE MADE IN ALUMINIUM.

Kindly mention this paper when enquiring or ordering.

WHITTAKER'S IMPROVED MOULDING MACHINE

By which Wheels or Pulleys of any description or size from 3 inches to upwards of 20 ft. diameter can be made.



THE MOST COMPLETE AND EFFICIENT MACHINE HITHERTO INTRODUCED TO ENGINEERS.

All Machines warranted to Mould with the greatest accuracy and precision.

GEARING WHEELS

Spur or Bevel, Straight Teeth and Double Helical Teeth Supplied to Consumers.

ROPE & BELT PULLEYS.

WM. WHITTAKER & SONS, LTD.,

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Index to Advertisers.

Addresses, Telegraphic Addresses, and Telephone Numbers.

PAGE.	NAME.	ADDRESS.	TELEGRAPHIC ADDRESS.	TELEPHONE NO.
573	Adaptable Moulding Machine Co.	Stanhope Street, Birmingham	"Adaptable"	1966 Mid.
564	Alldays & Onions, Ltd.	Birmingham	Alldays, Birmingham	28 Victoria
571	Anglo-Mexican Petroleum Products Co., Ltd.	Finsbury Court, Finsbury Pavement, E.C.	Mexproduct, Ave, London	City 2704
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566	British Binderit Co., Ltd.	Wharf Road, Wandsworth, S.W.	Bindercomp, Wands., London	994 Putney
C. ii.	British Thermit, Co., Ltd.	49 & 51 The Albany, Liverpool.	Thermetal, Liverpool	1680 Central
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566	Williams, J. (Birmingham Sand), Ltd.	Birmingham	—	—

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The Monometer Oil Burner is the latest and best on the Market. Will burn crude and residual oils without smoke or deposit. Suitable for firing furnaces for the melting and heat-treatment of metals and all heating purposes.

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for the melting and heat-treatment of metals. Fitted with Patent combustion chamber and Oil Burner, will successfully and economically burn crude and residual oils, with perfect combustion and without carbon deposit.

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Edited by I. H. Hall, Managing Director.

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1. Dense with close grey fracture.
2. Melts hot and exceedingly fluid and will fill every corner of your Mould.
3. Easy to Machine.
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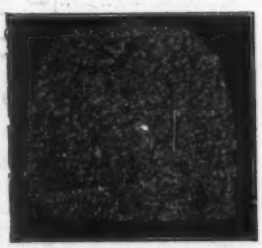
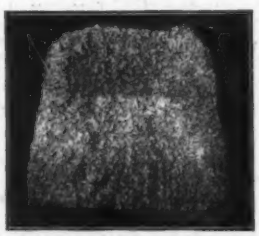
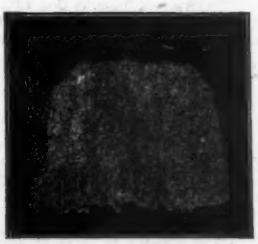
Contractors to the Admiralty, Principal Railway Companies and Engineers at Home and Abroad.

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is extremely useful for Mould Drying, Cupola Lighting, and for a variety of heating purposes in the Foundry, and a very intense heat can be obtained in a few minutes if so desired.

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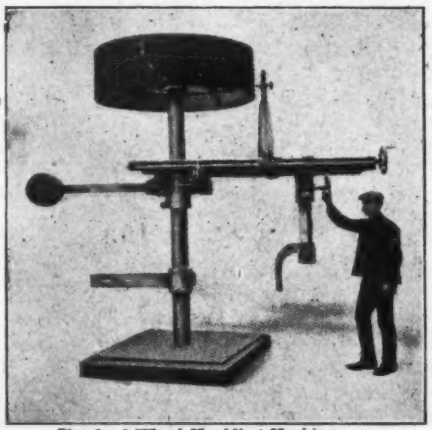

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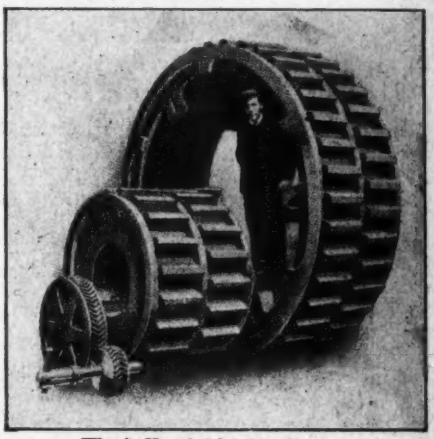
SHOULD BE EQUIPPED WITH

STEWART WHEEL MOULDING MACHINES.

Complete Satisfaction Guaranteed



Wheels Moulded by this Machine.

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ACCURATE. PORTABLE. CHEAP.

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FOUNDRY BLACKINGS

OF ALL KINDS

COAL DUST, CHARCOAL, PLUMBAGO and BLACK-LEAD CORE GUMS and all Foundry Requisites, and have done so since 1831.

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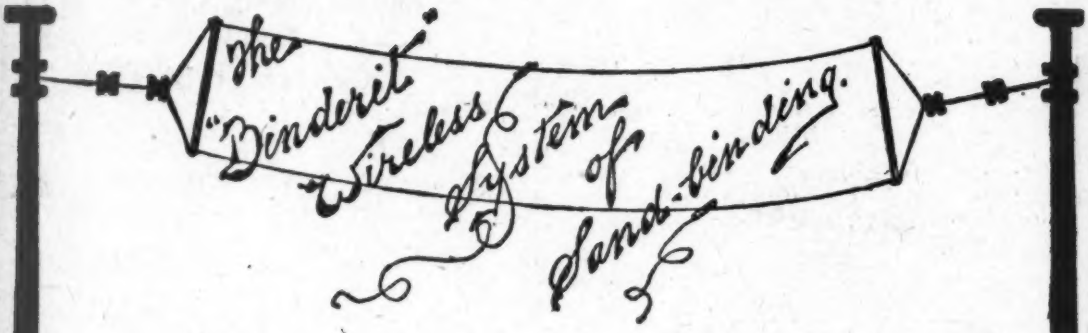

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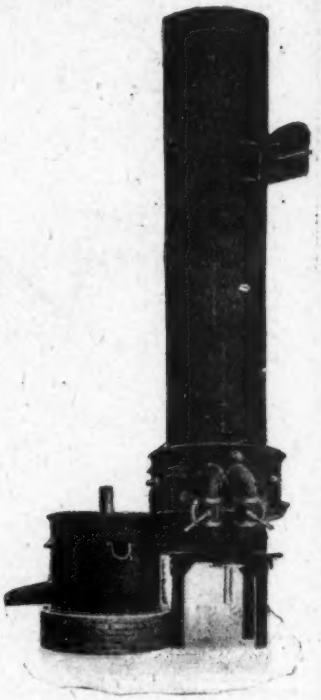

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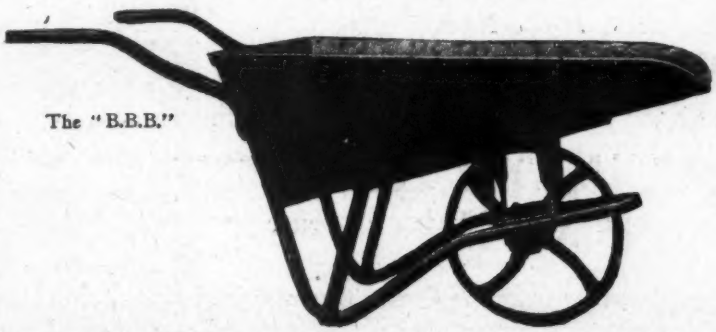

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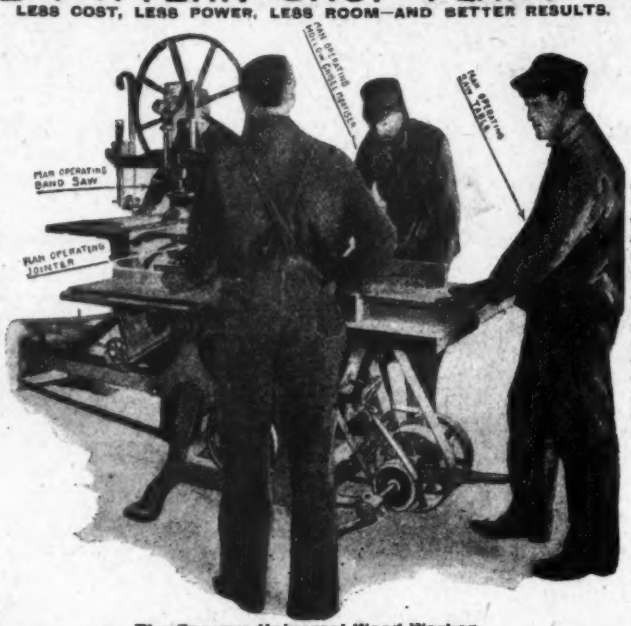

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